

**MAKING "INVISIBLE ARCHITECTURE" VISIBLE: A  
COMPARATIVE STUDY OF NURSING UNIT TYPOLOGIES IN  
THE UNITED STATES AND CHINA**

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Hui Cai

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**MAKING "INVISIBLE ARCHITECTURE" VISIBLE: A  
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Approved by:

Dr. Craig Zimring, Advisor  
School of Architecture  
*Georgia Institute of Technology*

Dr. Sonit Bafna  
School of Architecture  
*Georgia Institute of Technology*

Dr. Ellen Yi-Luen Do  
College of Architecture & College of  
Computing  
*Georgia Institute of Technology*

Dr. Mardelle Shepley  
Center for Health Systems & Design  
*Texas A & M University*

Dr. Ermal Shpuza  
Department of Architecture  
*Southern Polytechnic State University*

Dr. Xiqiu Huang  
*China IPPR International Engineering  
Corporation*

Date Approved: [05 04, 2012]

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## SUMMARY

Rapidly increasing needs for better healthcare in China are resulting in massive investments in healthcare facilities. This once-in-a-lifetime construction boom provides a valuable opportunity to rethink Chinese hospital design, and especially to consider how to design modern hospitals that are effective and efficient in delivering care, and are responsive to the cultural needs of the Chinese people as well.

The particular socio-cultural factors under consideration in this study focused on communicational needs that had been identified as being very important for the optimum organizational performance of nursing units. The study identified these needs through a thorough review of both the national schema and the organizational culture of Chinese nursing units. The specific communicational needs of Chinese care teams were then translated into spatial metrics based on an extensive review of previous space syntax studies on spatial configurations and communication.

In order to find out whether Chinese nursing unit designs have been adapted to fit specific models of communications which were strongly influenced by culture, an in-depth comparative study was developed that included six U.S. and six Chinese nursing units, with each representing an example of one nursing unit typology. The comparisons were conducted under a holistic framework encompassing four main factors as drivers of nursing unit designs: space economy, staff efficiency, access to optimal (southern) natural light, and cultural preferences in terms of face-to-face communication. Key metrics were proposed for a quantitative evaluation of each factor. For space economy, measurements included corridor length per bed, corridor length per patient room, area per bed, and the composition of various zones. Staff efficiency measures included furthest distance from nursing station(s) to patient rooms, average distance from nursing station(s)

to patient rooms, and average distance from nursing station(s) to patient beds. For natural light, the percentage of patient beds that have access to southern sunlight was calculated. To evaluate how space supported cultural preferences of communication, spatial metrics were proposed; including mean connectivity, mean integration, intelligibility of the layout, and the rank order of integration values of various functional zones for the analysis on visibility and accessibility. The number of axial lines per space and the structure of colored axial maps were also taken into consideration.

The results revealed significant national differences in the application of unit typologies between the U.S and China. It shows that Chinese nursing unit designs have been modified from the Western precedents to adapt them to local economic conditions, different requirements for efficiency, the Chinese preference for southern natural light, the task-based care model, and the unique socio-cultural needs as defined by the Chinese national schema.

This study is the first of its kind exploring the cultural dimensions of nursing unit designs. It provides a comprehensive description of the design evolution of Chinese healthcare architecture, with a special focus on nursing units. Moreover, it provides an in-depth examination of the relationship between nursing unit typologies, communication, and the complexity of national and organizational culture in healthcare settings. The theoretical framework, the research methodology, and the findings can be applied beyond the Chinese nursing units and extend to other cultural and organizational contexts.

# CHAPTER 1

## INTRODUCTION

China is facing the largest health care construction boom in its history. It will be building over 2,000 new hospitals and hundreds of thousands of clinics over the next decade, providing healthcare for hundreds of millions of people (The China Central Committee and the State Council, 2009). The forms of these hospitals are determined by a range of influences. Among these influences are economics, the precedents provided by Western healthcare architecture and care processes, and the cultural expectations of patients, family and staff. The aim of this dissertation is to explore these issues and particularly to understand how cultural preferences are expressed in the nursing unit designs of modern Chinese hospitals. This is similar to what Kizer (2010) described as “invisible architecture,” which refers to the “values, culture, and emotional climate” of a health care organization.

The dissertation is organized in three sections (Figure 1.1). In Section I, *Theoretical Exploration*, it addresses several aspects of the context that forms Chinese healthcare: economic condition, insurance practices, the availability of funding, patient profiles, care models, staffing, care philosophies, and cultural preferences regarding organizational communication. Several steps are undertaken to identify key drivers of nursing unit design and link them to quantifiable spatial metrics. Chapter Two reviews existing studies on nursing unit designs. It highlights space economy, staff efficiency, natural light and ventilation as important factors that drive design. Existing metrics based on these factors are discussed. Moreover, it reveals how cultural preferences in communication are an important factor that impacts nursing unit design, yet have largely been neglected in current research.

This is followed by a discussion of face-to-face communication in the healthcare environment, focusing particularly upon communication’s characteristics in the context

of the inpatient unit (Chapter Three). The first task is to examine the importance of communication in improving care team collaboration, healthcare delivery, and knowledge distribution. The second part of the chapter clarifies our understanding of face-to-face interactions as the most important mode of communication in the healthcare settings. The third part of the chapter explores the characteristics of hospital space that facilitate the communication of care teams.

Chapter Four identifies the cultural properties of communication in Chinese nursing units. The following questions are investigated: “what are the cultural aspects of communication in Chinese inpatient units?,” and “what are the most relevant spatial qualities that might affect face-to-face communication in Chinese nursing units?” To understand the cultural aspects of communication, both national schema and organizational culture are carefully reviewed based on a multidisciplinary approach. The Chinese national schema is explored through an extensive review of cross-cultural organizational communication and studies of Confucianism. Further, the working definition of organizational culture is refined in Chapter Four by examining the Chinese healthcare system and the staffing and care model in Chinese nursing units. The spatial implications of both the Chinese national schema and organizational culture are discussed.

Chapter Five further translates cultural properties of communication into spatial metrics, with the help of the space syntax theory. Space Syntax has been proven to be effective in linking space, movement and communication in offices, labs, and museums (Grajewski, 1993; Hillier & Penn, 1991; Penn, Desyllas, & Vaughan, 1999; Peponis et al., 2007; Serrato & Wineman, 1999), as well as revealing the cultural inputs reflected in the configurations of buildings (Hillier & Hanson, 1984). Through an extensive review of existing space syntax studies on the impact of spatial configurations on communication,

this chapter defines the spatial measures that are most relevant for representing the cultural properties of space that impact face-to-face communication.

The second section of this dissertation, *Empirical Case Studies*, examines the differences of nursing unit designs between China and the U.S. through an extensive, comparative study of the plans of six U.S. and six Chinese nursing units (Chapter Six). Each case study represents an example of a nursing unit typology. All cases are analyzed carefully using the metrics identified during the first section. Three different levels of comparisons are made: (1) a comparison of the plans of various typologies among American and Chinese cases; (2) a comparison of American and Chinese cases with the same typology; and (3) an overall comparison of American and Chinese cases.

The third section (Chapter Seven) integrates knowledge from the theoretical exploration of the Section I and the empirical case studies of Section II. It summarizes the major findings of this dissertation and discusses the implication of these findings at theoretical, methodological, and design levels. It concludes with an examination of the limitations of this study and suggests directions for future work.

Section I Theoretical Exploration	Section II Empirical Case Studies	Section III Integrated Discussion
<ul style="list-style-type: none"> <li>• Ch.2: Nursing unit typology</li> <li>• Ch.3: Face-to-face communication in healthcare environment</li> <li>• Ch.4: Cultural aspects of communication</li> <li>• Ch.5: Space syntax, communication and other organizational constructs</li> </ul>	<ul style="list-style-type: none"> <li>• Ch.6: Comparative study on the selected United States and Chinese nursing unit layouts</li> </ul>	<ul style="list-style-type: none"> <li>• Ch.7: Discussion on the impacts of culture on nursing unit designs</li> </ul>

Figure 1.1: An outline of the dissertation.

## **1.1 Research Background**

Rapid economic growth and the increasing need for better healthcare in China have led to massive investment in healthcare facilities and a mandate for higher quality healthcare design. The Chinese government recently announced the largest healthcare construction program in history, a \$124 billion (850 billion RMB), three-year overhaul of the Chinese healthcare system that vastly expands access to care (The China Central Committee and the State Council, 2009). The government expects to build or substantially modernize:

- 2,000 new county hospitals;
- 29,000 new and 5,000 renovated village health stations and rural township health centers;
- 3,700 urban health centers;
- 11,000 community health stations;
- Numerous urban hospitals, especially in the smaller Tier 2 and Tier 3 cities (The China Central Committee and the State Council, 2009)

This once-in-a-lifetime construction boom provides a valuable opportunity to rethink Chinese hospital design, and especially to consider how to design modern hospitals that are effective and efficient in delivering care, and are responsive to the socio-cultural needs of the Chinese people as well.

The hospital, as a highly specialized building type to provide professional patient care, was introduced into China by medical missionaries who arrived in the 1840s (Renshaw, 2005). Prior to the 19<sup>th</sup> Century, healthcare was primarily provided at the homes of physicians or patients. Only a few early forms of “medical institutions” existed, such as hospice, pharmacies, state-run charity infirmaries, and poorhouses with limited accommodations for the sick. During and after the 1840s, with the gradual dissemination of the concept of the modern hospital in China, the design of hospitals has gone through

several phases of transition. The early phase combined traditional Chinese architectural traditions with the Western hospital layout to create designs that appealed to local Chinese people. The second and third phases have been characterized by the active exploration of efficient layout and the adoption of the modern “international” style. Following the opening of a market-driven economy in the early 1990s, an even greater Western influence has been seen in the design of contemporary Chinese hospitals, due to the increased exposure of native designers to the latest design trends, and to the increased frequency of collaboration with international design firms (Liu, 2006).

However, it is unclear to what extent the seemingly modernized Chinese hospitals retain characteristics of Chinese cultural preferences and spatial behaviors. The cultural dimension of hospital design has been largely ignored in recent research. There is a lack of evidence to support design decisions that respond appropriately to the socio-cultural needs of Chinese communities.

## **1.2 Research Question and Scope**

Therefore, this study aims to explore whether Chinese hospital designs are identical with their counterparts in the U.S or they have been adapted to the socio-cultural needs of Chinese. Furthermore, it aims to link the spatial properties of Chinese hospital design with the contextual factors, such as economical condition, insurance policy, funding, patient profiles, staffing model, care philosophy, and particularly cultural preferences regarding organizational communication.

In this study, the scope of the hospital space under consideration is limited to nursing units only. The nursing unit is “a group of inpatient beds with a central nurse/communication station and all the functions necessary to provide care to the patients on the unit.” (Military Health System [MHS], 2008, p. 3) It can also be referred to as an inpatient unit. The nursing unit is one of the most important components of modern hospitals. First of all, according to the “Standards for Design and Construction of



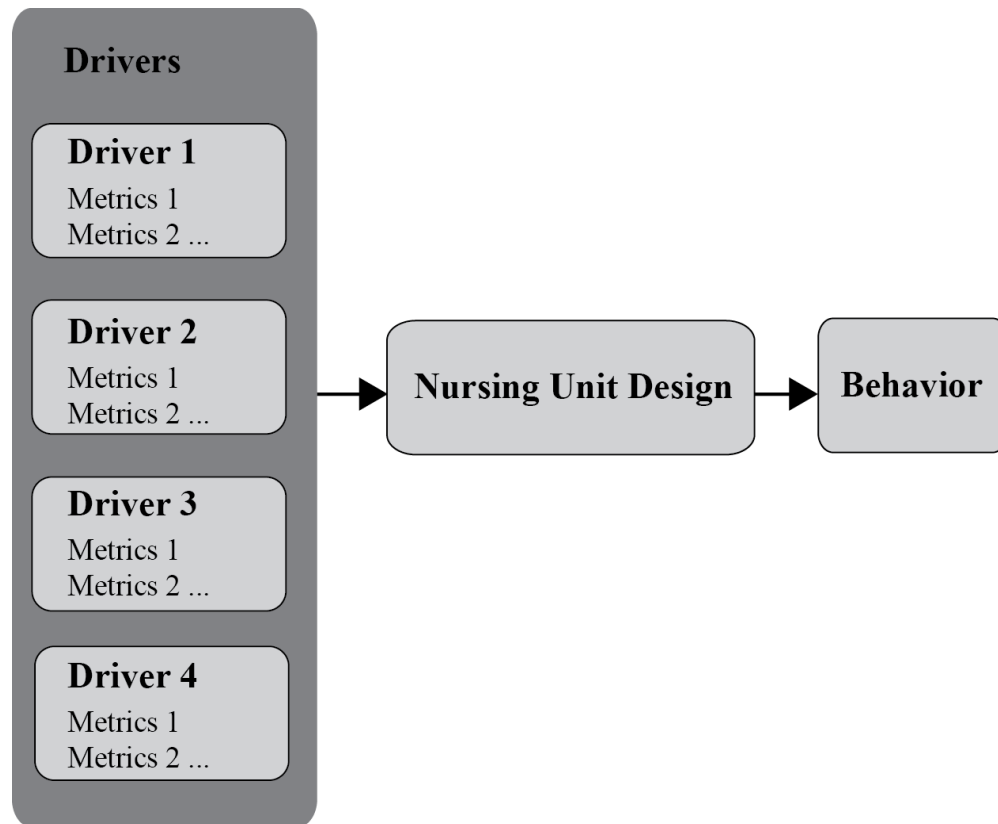
General Hospitals 2008 Edition,”(Ministry of Housing and Urban-Rural Development of the People's Republic of China [MOHURD] & National Development and Reform Commission, 2008) the inpatient department occupies about 39% of total construction area of the average hospital. In addition, the layout of nursing units is usually a strong determinant of the form of whole hospital. Furthermore, a nursing unit can be viewed as a miniature model of a society or an example of a “total institution,” where social and cultural rules are implemented through daily operations (Goffman, 1961). Therefore, studying nursing units will provide a good opportunity to understand the cultural inputs in built environment.

Although this thesis examines various contextual factors that drive nursing unit design, including economical condition, insurance policy, funding, patient profiles, staffing models, and care philosophies, it has a special focus on cultural preferences. Culture is of course an extremely broad and complex concept. This dissertation focuses on examining the issues of cultural preferences related to face-to-face communication from the caregivers’ perspective. Firstly, effective face-to-face communication among caregivers is imperative for the health delivery processes in nursing units. According to O’Daniel and Rosenstein (2008), during the course of a four day hospital stay, the care for one patient may involve 50 different employees, including physicians, nurses, technicians and other medical support staff. We argue that the design of the units should not only support the staff efficiency of conducting routine care tasks, but also facilitate face-to-face communications. Secondly, as a carrier of culture, communication patterns are strongly impacted and regulated by culture (Chen & Starosta, 1998). According to Zimring and Peatross (1997), the cultural aspects of buildings can be defined as an interrelated system of four elements: *organizational rules and structures* about the nature of tasks; the *national schema* or ethnic characteristics; *space*; and *behaviors* such as actual encounters and communication. They believe that national schemas and

organizational rules and structures affect “the direction of communication, mode of communication, groups sizes involved with decision-making, the nature of people involved with decision-making, and the mode of supervision and control exercised.” (Zimring & Peatross, 1997, p. 210) Therefore, cultures can be analyzed in terms of their patterns of symbolic identification and communication. Design of the physical environment should be an element that both reflects the culture and mediates the characteristics of these patterns. Zimring and Peatross’s work on the cultural aspects of the workplace provides great insight into how culture is embodied in space and behavior. That work is the foundation of the theoretical framework employed here.

### **1.3 Conceptual Model**

This dissertation views the design of nursing units as a balancing act involving various combinations of several driving factors. A conceptual model is proposed to link multiple, key drivers of inpatient unit design and their related spatial metrics with nursing unit configurations and behavior (Figure 1.2). Culture is one factor among these drivers for nursing unit design.



**Figure 1.2: Conceptual model of the interrelationship between key drivers of nursing unit design, space and behavior.**

## 1.4 Research Goals

Hence, the first goal of this thesis is to identify some key factors that drive Chinese nursing floor design, and link them to quantifiable spatial metrics. A special focus is on examining the cultural preferences on face-to-face communication and the related spatial metrics that can be applied to measure cultural aspects of communication in Chinese inpatient units.

The second goal is to use the proposed metrics to compare the U.S. and Chinese nursing unit typologies. The intent is to discover whether and how socio-cultural differences are reflected in spatial configurations.

## **SECTION I: THEORETICAL EXPLORATIONS**

## **CHAPTER 2**

### **NURSING UNIT TYPOLOGIES**

#### **2.1 United States and European Nursing Unit Design**

The nursing unit, or sometimes called inpatient unit, is one of the most important programmatic components of hospital. It is where patients stay in the hospital for at least one night during the course of treatment, examination or observation. The unit is usually composed of patient and family/visitor area, staff area and circulation. Patient area includes patient rooms, patient amenities such as patient toilets, bathrooms, and day room. Family/visitor area is composed of lounge space, restrooms and possibly overnight accommodations. Staff area consists support functions of patient care, including nurse station, treatment room, utility room, kitchen/nourishment room, doctors' office, nurses' office, staff amenities such as staff toilet and duty room, and sometime teaching areas such as clinical teaching room and seminar room. Circulation refers to both the primary public corridors and hallways that access entries, exits, stairs, and elevators and the secondary corridors and hallways that link rooms together.

The design of nursing units is of vital importance to the efficiency and effectiveness of care (Thompson & Goldin, 1975). It has to balance several seemingly conflicting needs, i.e. patient privacy and ease of surveillance for nurses, the capacity/size of nursing unit and nurse walking distances, access to natural light and the depth of layout, the efficiency and privacy of backstage communication within the care team and the effectiveness of frontstage communication between caregivers and patients/families. As a result, the design of nursing units has experienced multiple transformations during last few decades (see Figure 2.1). Each new development in nursing unit typologies can be viewed as an attempt to solve some specific issues while balancing other

considerations. Next, we will provide a historical review of nursing unit designs based on the nursing unit typologies proposed by James and Tatton-Brown (1986).

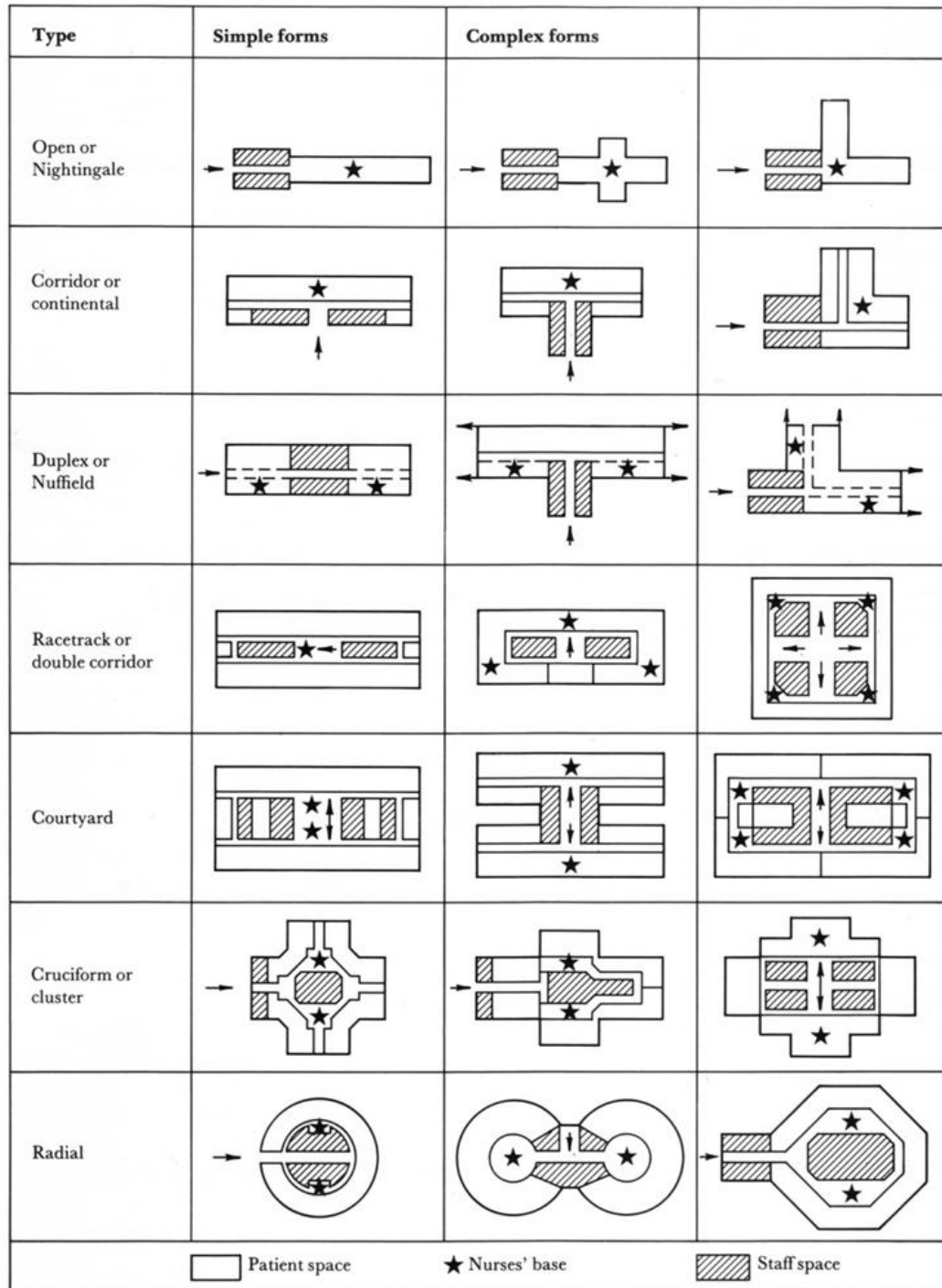
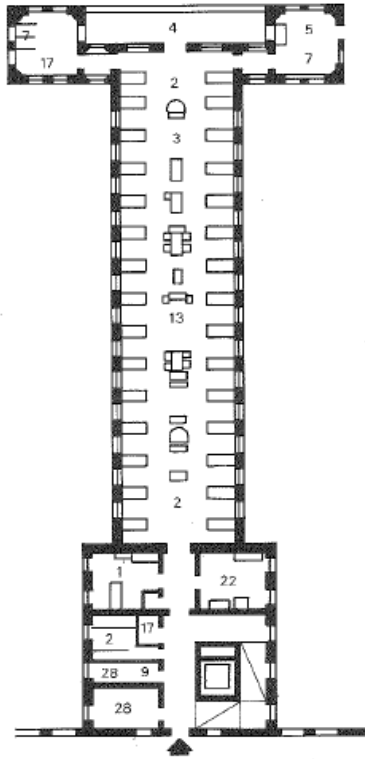


Figure 2.1: Nursing unit typologies, source: (James & Tatton-Brown, 1986, p. 76).

## **2.1.1 Historical Evolution of Nursing Unit Typologies**

### **2.1.1.1 Nightingale Ward**

The early nursing unit is based on the open ward or Nightingale ward, which focuses on providing maximum visual surveillance from nurses. The unit usually has a large open ward with 30-36 patient beds. The beds are placed perpendicular to the exterior walls. Windows are placed in-between every two patient beds. Windows usually take up at least one third of the wall space (Thompson & Goldin, 1975). Cross ventilation and natural light are well acquired through the open-ward design. The nurse station is placed in the middle of the ward to facilitate surveillance. Support area for nurses' service is attached to one end of the ward. The patient amenities are towards the other end of the ward. There is no corridor. All circulation has to go across the center of the ward, which increases the risk of cross contamination. In order to offer more patient beds capacity, designers usually apply cruciform or L shape to multiple units, while placing the nursing station in the middle for ease of surveillance. One typical example of open ward is the south wing of St. Thomas hospital built in 1867 (Figure 2.2). It has a 30 beds open ward, with nurses in the middle. The wing is placed along a north to south axis to gain best sunlight. The patient amenities are attached on the east end of the ward, with a balcony. The nurses' service area is attached to the west end. There is one single patient room right next to nurse office, for patients with more serious conditions.



**Figure 2.2: St. Thomas Hospital, South wing, London, UK, 1867 (Source: James & Tatton Brown, 1986, p. 77).**

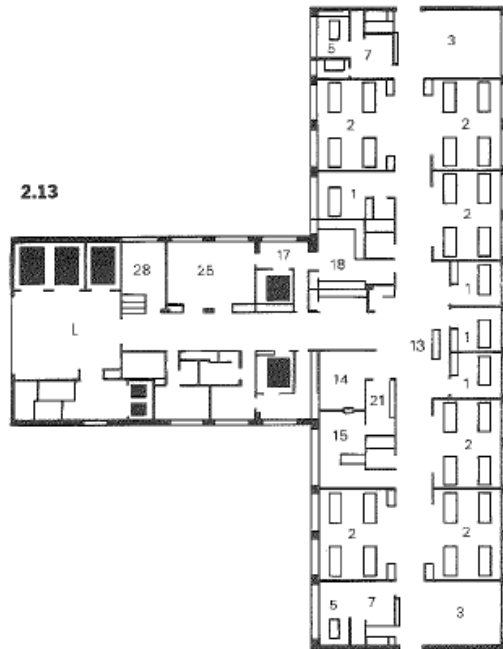
#### 2.1.1.2 Single Corridor

To solve the problem of cross contamination, corridor and more subdivisions between patient beds are introduced into nursing unit design. The overall unit size is still about the 30-36 beds. However it is composed of several smaller multiple patient bed ward and some single patient rooms. Patient rooms are usually placed on one side of the corridor, usually the side with optimal sunlight. The nurse service areas are placed on the other side of the corridor. Nurse station sits in the middle of the unit for the sake of shortest walk distance and the ease of surveillance. The corridor is used as the main circulation to connect various functional zones.

One example of corridor typology is the east wing of St. Thomas built in 1960. It is based on a t-shape floor plate (Figure 2.3). The service area is attached perpendicular



to the patient area. Nurse station is placed at the joint between the patient zone and staff zone, to overlook the main circulation. Most patient beds are located in four-bed ward. A few single patient rooms are supplied for patients with serious conditions. Patient amenities such as day room, toilets and bathrooms are located at two ends of the patient wing.

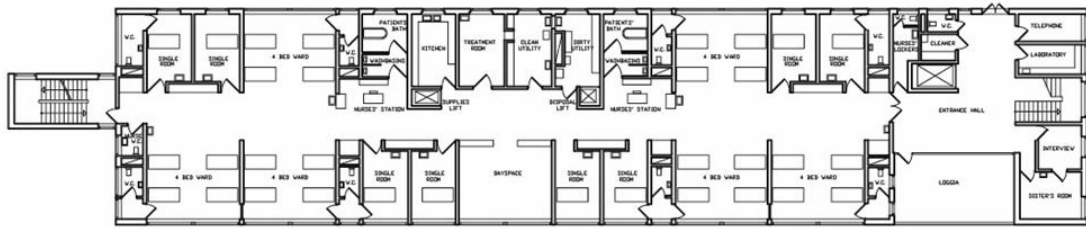


**Figure 2.3: St. Thomas Hospital, East wing, London, UK, 1960 (Source: James & Tatton Brown, 1986, p.79).**

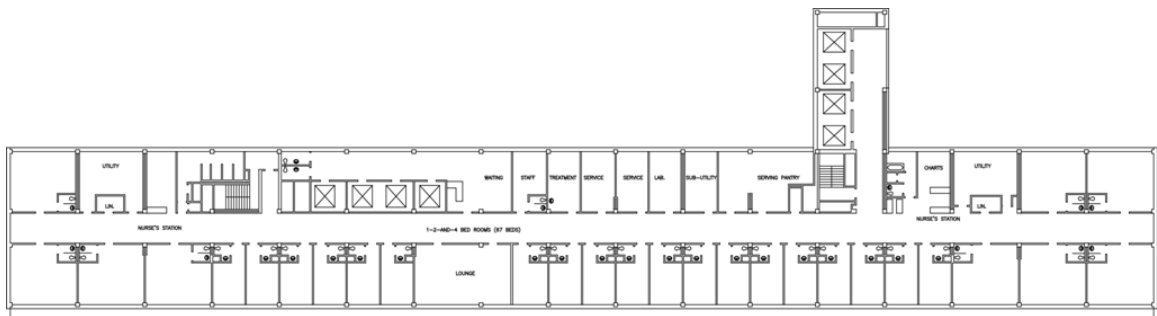
#### 2.1.1.3 Duplex

One of the solutions implemented to reduce the walking distance and work load of nurses is to apply team nursing and divide one large unit into two smaller equal sections with up to 20 beds, which is called duplex layout (James & Tatton-Brown, 1986). For instance, in the Larkfield Hospital (Figure 2.4), they split the ward into two equal sections of 16 beds, each with its own nurse station. Nursing ancillary space is shared between the two sections. Four single rooms are provided, two on each section for patients with serious conditions and patients who are socially unacceptable. Patient beds

are placed parallel to exterior wall. Windows on both sides of the walls provide good natural light and ventilation (Farrer-Brown, Carling, Walker, & Tyndall, 1955). The duplex plan works well for multiple-bed wards. However, when the multi-bed ward is replaced by single patient room, the corridor gets quite long. For instance, in the case of the NYU Bellevue Medical Center built in 1948, it is composed of two sections, each with its own nurse station. The nursing ancillaries and a patient lounge are shared in between two nurse sections (Figure 2.5). The overall unit has 67 beds, with 1, 2 and 4-bed rooms. The corridor length is even longer than double the length of corridor of the Larkfield Hospital, 385 ft vs. 157.44 ft respectively.



**Figure 2.4: Larkfield Hospital, UK, 1960 (Source: James & Tatton Brown, 1986, p. 81).**

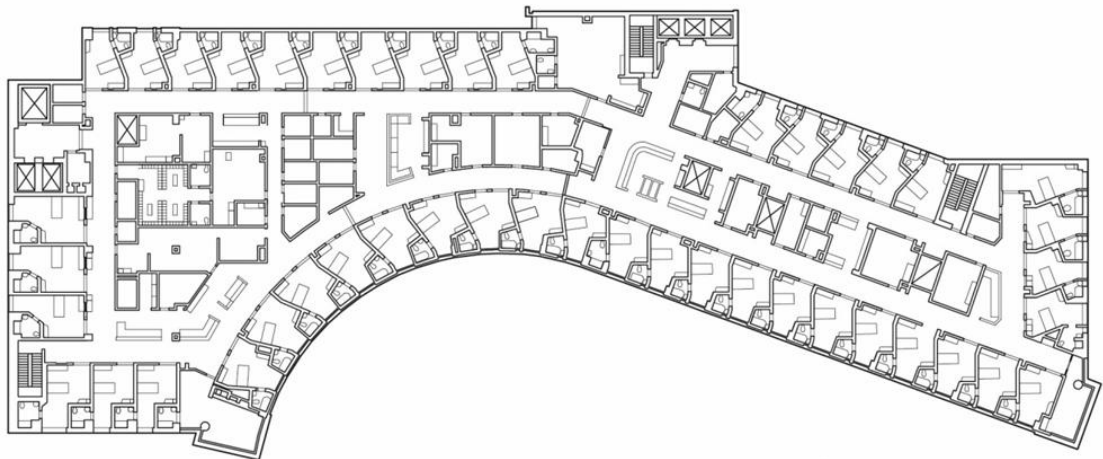


**Figure 2.5: NYU Bellevue Medical Center, the United States, 1948 (drawn by author).**

#### 2.1.1.4 Racetrack or Double Corridor

The length of corridor becomes a challenge in countries with higher expectation for privacy and greater needs of single patient rooms. In the U.S., the needs for privacy are much higher than in Europe. Since 1950s, most hospitals in the U.S. have applied private or semi-private patient rooms (Thompson & Goldin, 1975). In order to fit more

patients without increasing the nurses' walking distance, designers propose racetrack plan or double corridor plan. The racetrack plan is based on a redundant circulation instead of a one-way circulation. The nurse station and other shared service and ancillary space are placed in the core. The development of air-conditioning and mechanical conveyor has contributed to the racetrack layout (James & Tatton-Brown, 1986). The optimal indoor air quality is maintained through the HVAC system. The patient rooms can get natural light, yet the staff work areas are in the "dark rooms" that have to rely on artificial lighting. Due to its compactness and relative efficiency in walking distance, the racetrack layout is still one of the most popular configurations for nursing unit design in the U.S. The recently designed St. Joseph Hospital in Minnesota applied the racetrack typology (Figure 2.6). It has 45 single patient rooms, which are arranged at the perimeters of the floor plate. There are six nurse stations with various sizes and layout, each covers different number of patient rooms. All the service areas are located at the core of the layout between the racetrack corridors. The operation of the unit relies heavily on mechanical ventilation and artificial lighting.



**Figure 2.6: St. Joseph Hospital at St Paul, Minnesota, the United States, 2005 (drawn by author).**

#### 2.1.1.5 Courtyard

The courtyard layout is introduced as an alternative to traditional racetrack layout to provide better natural lighting and ventilation to the staff. In this typology, one or more courtyards are inserted in the core area of the plan. The service areas are laid out around the courtyard. Since patient rooms are further apart on the courtyard plan, designers usually use de-centralized nurse stations to provide care for sub-groups of patients. Hence this type of plan is better supported through team-based nursing model. The width of the floor plate is greatly increased by the courtyard. This typology is applied often in Scandinavia, Britain, and Asia, as designers there are reluctant to accept a totally artificial working environment (James & Tatton-Brown, 1986).

A typical example of courtyard typology is represented by the case of York District Hospital (Figure 2.7). It contains four 30-bed ward sections, each with a nurse station located at the corner of the racetrack corridors. All the patient rooms are arranged along the external perimeter while all nursing ancillaries are arranged along the internal perimeter around the courtyard.

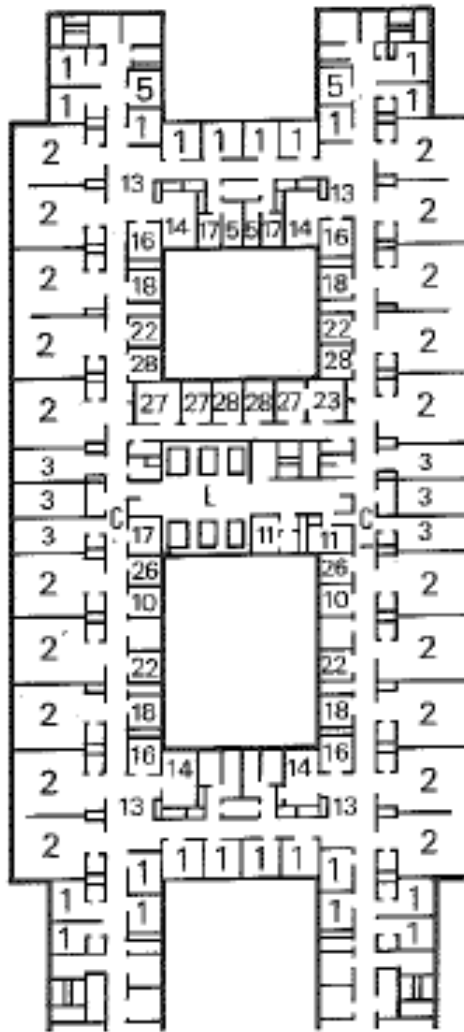


Figure 2.7: York Hospital, UK, 1967 (Source: James & Tatton Brown, 1986, p. 85).

#### 2.1.1.6 Cruciform or Cluster

Courtyard plans do provide more patient privacy and natural light. However due to its increased depth of floor plate, it largely increases the walking distance of nurses and sacrifices the ease of surveillance and efficiency of care. During 1970s, designers have started to group patients into sub-units and move service into core area to share among different sub-units (James & Tatton-Brown, 1986). The cruciform layout is an example that responds to such design drivers. It divides the nursing floor into four sections, with

the service and nursing base located in the center of the cross. It allows for better visibility from nurse station to circulations and shorter walking distances (Figure 2.8). However, the direct surveillance from nurse station to patient rooms is still limited. An innovative modern solution is in the case of St. Joseph Hospital at West Bend (Figure 2.9). This 34-bed ward has one central nurse station located in the middle of the cross and 34 distributed nurse alcove in front of each patient room.

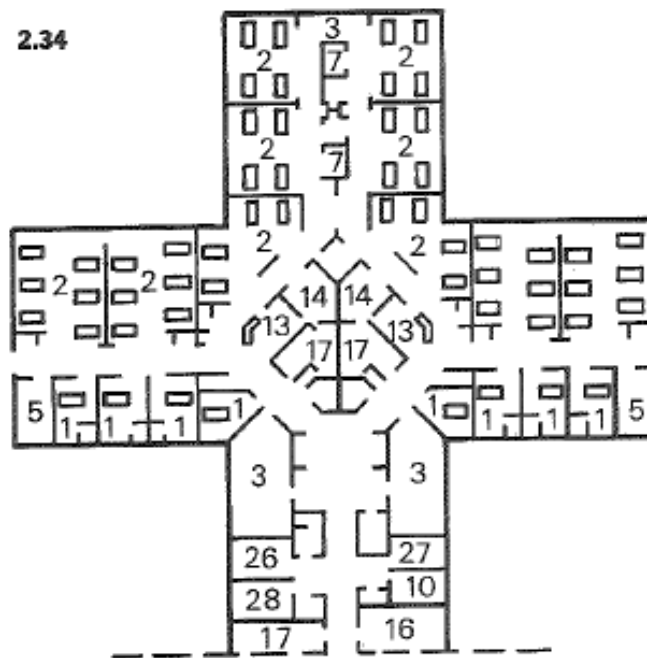
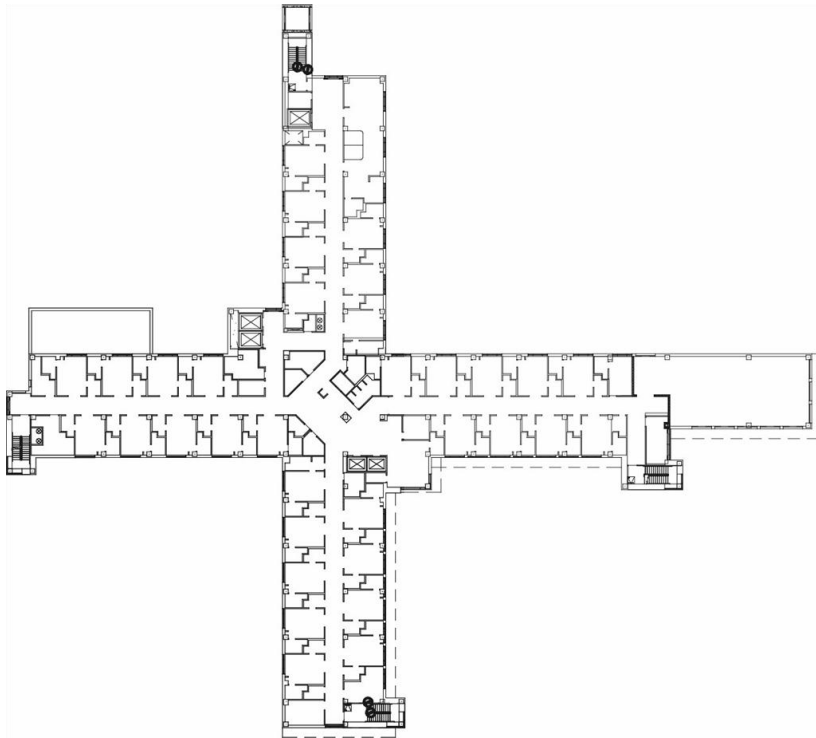


Figure 2.8: Southlands Hospital, Shoreham, UK (Source: James and Tatton-Brown, 1986, p.86).



**Figure 2.9: St. Joseph Hospital at West Bend, Wisconsin, the United States, 2009 (drawn by author)**

Another solution is to develop each sub-unit as a cluster, with the sub-nurse stations placed in the middle of each cluster. The nursing ancillaries are located in the center of the layout to be shared among the different clusters. The cluster layout has gained great popularity due to its efficiency in both patient supervision and walking distance. Hasbro Children's Hospital in Rhode Island provides a good example of the cluster layout (Figure 2.10). It has three sub-units/pods, each with 10 beds and one sub nurse station. The central pod locates most nurse service functions. A diagonal corridor leads patients and family members who arrive at the elevator lobby through the central pod and reach the reception desk.

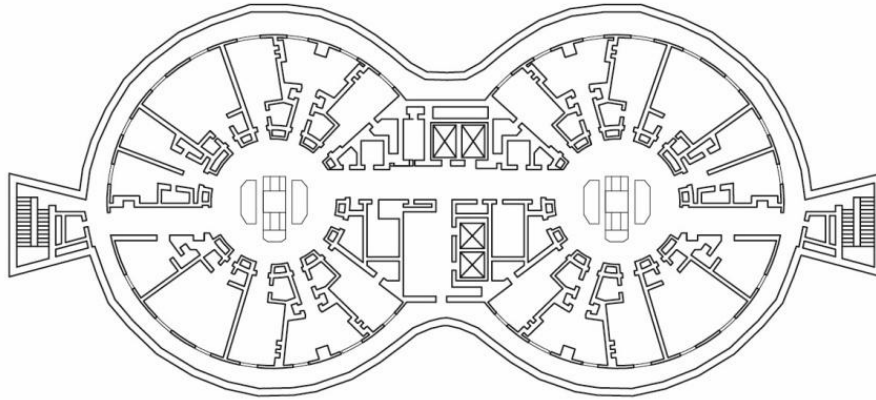


**Figure 2.10: Hasbro Children's Hospital, Providence, Rhode Island, 1994 (drawn by author).**

#### 2.1.1.7 Radial

Radial layout is also applied as a solution to achieve the shortest walking distance and optimal surveillance for nurses. The staff service area is placed at the core, with the nurse station at the center of the unit, where the nurses can have the best visibility towards patient rooms. Most patient rooms are kept at the same distance with the nurse station. The downside of the radial design is that the irregular shape of patient rooms creates difficulty of equipment and furniture arrangement. The radial or hexagon shape also has the issue of inflexibility for future expansions (Faulkner, 2002). The Kaiser Foundation Hospital (Figure 2.11) is an interesting application of radial layout. It is composed of two radial-shape sub units with the support area shared in the middle. For each sub-unit, the nurse station is located in the middle to guarantee maximum visibility towards patient rooms and shortest walking distance. The patient rooms are arrayed around the nurse station. Another interesting feature is the separation of family circulation and staff circulation. An external circular corridor that is wrapped around the perimeter of the unit is designed to be used by family and visitors; while an internal circular corridor is designed to be used by care givers.



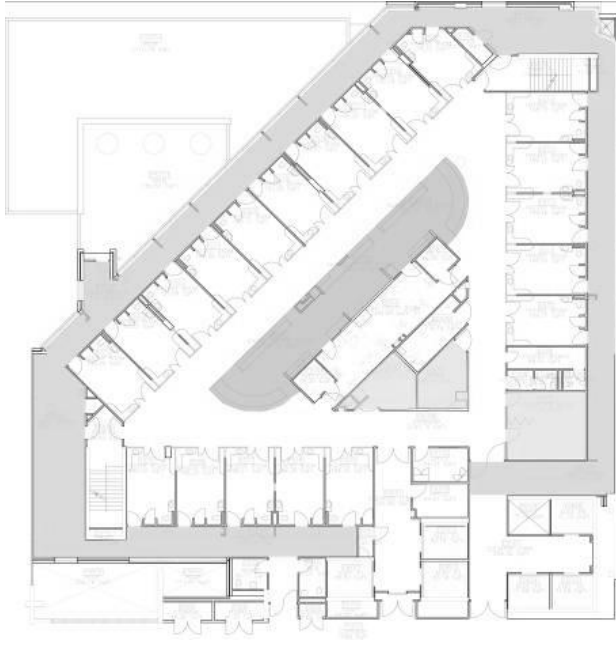


**Figure 2.11: Kaiser Foundation Hospital, CA, the United States, 1960 (drawn by author).**

#### 2.1.1.8 Triangular

Triangular layout is another solution to shorten the nurses' walking distance. The nurse station is usually placed in the middle of the layout to monitor patients. The staff support area and other ancillary areas are located at the center of the triangular layout for saving nurses' footsteps. Although the triangular layout is quite efficient for nursing staff, it shares the similar problems of adaptability and flexibility with radial layouts (Faulkner, 2002).

In the case of Emory 5E ICU, the patient rooms are arranged on three sides around a triangular-shape interior corridor (Figure 2.12). Two nurse stations and support areas are located in the middle of the triangular unit. Nurses mainly use the corridor that is located between the nurse service area and the patient rooms to move around and conduct care tasks. Due to the limited size of the core, the family accommodation is arranged around another triangular-shape corridor, wrapping around the perimeter of the unit. As a result, patient rooms have only access to indirect natural light.

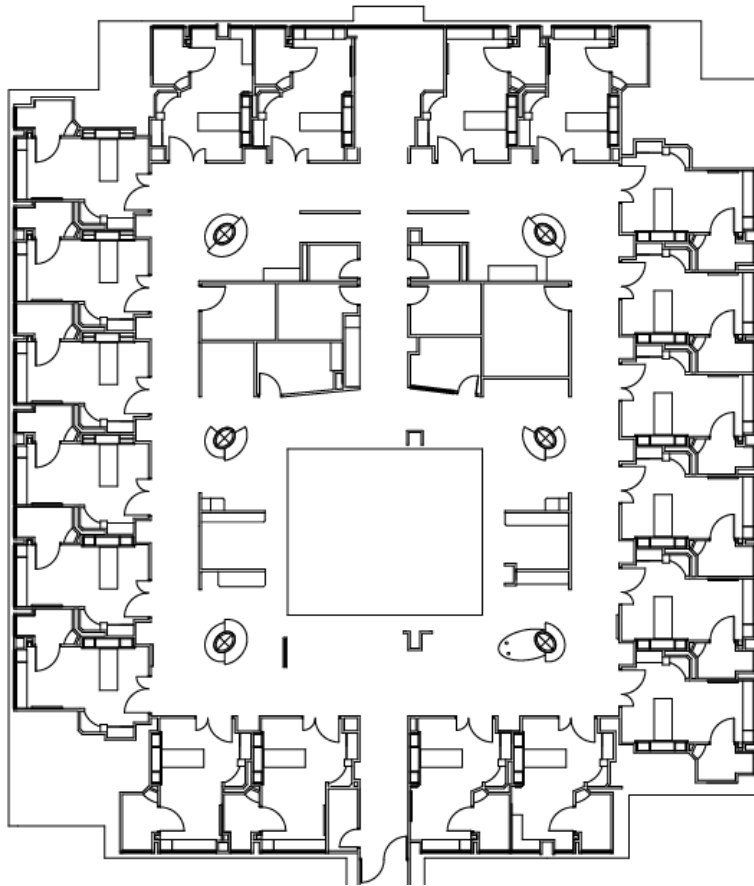


**Figure 2.12: Emory 5E ICU, Atlanta, GA, (Source: HKS, Inc.).**

#### 2.1.1.9 Distributed

Recently, due to the development of information technology, the shift of care model from caregiver centered to patient centered healthcare, more and more hospitals have adopted the distributed layout. Nurse stations are designed as alcoves distributed between every pair of patient rooms, so that they have more time working close to patient beds. These alcoves usually include work surfaces for charting and telecommunication devices. In addition, supplies are placed in every patient room or the alcoves outside patient rooms to save nurses time and travelling distance to get supplies. Ancillary space is in the core of the floor to allow minimum travel distance. Dublin Methodist Hospital in Ohio represents an innovative example that incorporated a lot of evidence-based design features, including the distributed layout with nursing alcoves and distributed supply, same-handed acuity-adaptable standardized room, and family area inside each patient room (Figure 2.13). It has an open core located around a courtyard, which provides natural light and view to the patient units. Shared support spaces are arranged around the courtyard to allow for natural light. In addition to the racetrack main circulation, there are

some cross circulations that allow shortcuts from one side of the unit to the other side, thus shorten nurses' walking distance. There is no central nurse base. Nurses' stations have been replaced by decentralized informal "perching" areas stocked with supplies. They are neutral areas without clear definition of ownership. Multi-disciplinary clinicians can drop by and work. They can also use these perches to meet with one another or with family members to discuss treatment details outside the patient room. In addition, there are distributed multipurpose alcoves outside each patient room. This distributed layout intends to push caregivers closer to patients and family members, and encourage the informal communications both between caregivers and family members, and among caregivers.



**Figure 2.13: Dublin Methodist Hospital, Ohio, the United States, 2007 (drawn by author).**

As aforementioned, a nursing floor usually consists of one or more nursing units. Based on different combination of nursing units, there is an almost infinite number of nursing floor typology, such as H-shape, Y-shape, L-shape, W-shape, windmill-shape, double circular, tripe circular etc. Those combinations are certainly important in hospital design. However, in this dissertation, we focus on the nursing unit as the basic element of research, and attempt to identify key spatial strategies that differentiate nursing unit typologies.

### **2.1.2 Key Spatial Strategies of Nursing Unit Typologies**

Based on the historical review of nurse unit evolution, we can see that the nurse unit design is a constant problem solving and new problem creating process. In other words, every innovation in design has some trade-offs. It meets certain needs yet sacrifices others. For example, the single corridor design during the 1940s ensured light and ventilation for patient rooms. But its long rectangle shape usually leads to long walking distances. The racetrack design during the 1950s focused on reducing walking distances by using the loop circulation and placing the nurse station and service core in the middle of the layout. However it limited visibility from the nurse station to some patient rooms. In addition, the large depth of the racetrack layout made it difficult to access natural light and ventilation. Courtyards were then introduced to provide natural light and ventilation with the price of larger footage and reduced visual surveillance. Cruciform and cluster layouts developed during the 1960s eased nurses' supervision by dividing a large unit into small sub-units and arranging patient rooms around the nurses' base in each sub-unit. But the feasibility of these designs relied on the staffing model that allowed nurses to be separated into small teams. Radial configurations of the 1970s and triangles of the 1980s went back to the idea of central nurse station. The nurses' base was placed at the center of the layouts to provide great visual surveillance and shorten travel paths for nurses. However radial and triangular layouts had limited space for support and

storage. The shapes of these layouts also made patient rooms fairly difficult to use and constrained the potential for architectural adaptability. Since 1990s, designers tended to decentralize the nurse stations and some related supply areas. It resolved the problem of the high levels of noise, crowd and the long walking distance caused by the centralized nurse station. It enabled the nurses to stay near to their patients and work with fewer interruptions. However it created new problem, as it might increase the perception of nurse isolation from other caregivers and decrease the social interaction and learning.

Overall, some key factors have been identified as main drivers for nursing unit design innovations: staff efficiency, space economy, access to natural light. Meanwhile, cultural factors, nursing traditions, organizational structure, and care model are equally important for the nursing unit design (James & Tatton-Brown, 1986).

The evolution of nursing unit designs is an attempt to balance the considerations of the above factors with some spatial strategies, such as the circulation theme, the distribution of nurses' base, and the shape of floor plate. Based on the variations of these three spatial strategies, we further simplified James and Tatton-Brown's nursing unit typologies into six types, single corridor, racetrack, cluster, radial, triangular, and distributed layout. The cases that we selected for detailed spatial analysis and comparative studies were based on these six typologies. The details are discussed later in Chapter 6.

## **2.2 Chinese Nursing Unit Typologies**

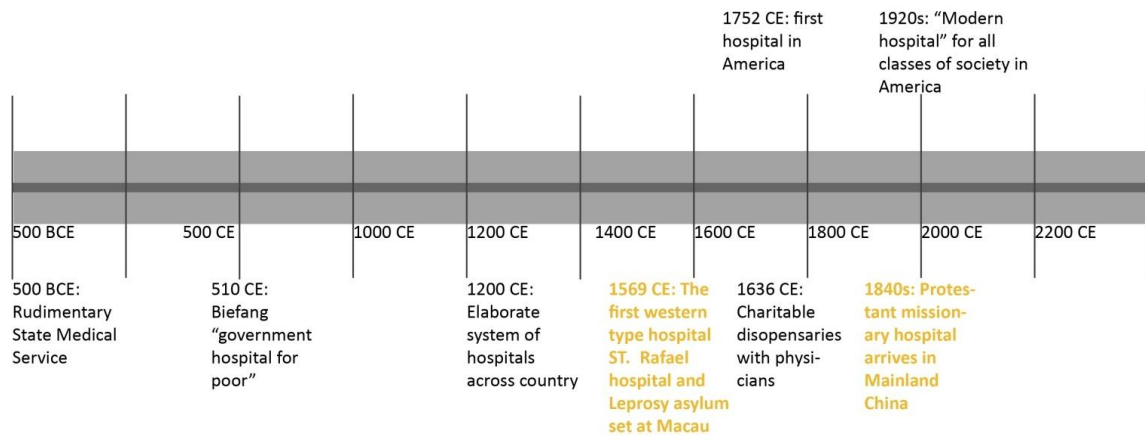
The above section has reviewed the historical evolution of nursing unit typology in the United States and European countries. The nursing unit design in China has experienced a parallel yet not entirely identical development process when compared to its Western counterparts. In this section, we provide a historical review of Chinese hospital design and particularly the evolution of nursing unit design. Some factors that might contribute to the differences in Western and Chinese nursing unit typology is

discussed. More detailed spatial analysis on Western and Chinese nursing units will be provided in Chapter 6.

### **2.2.1 A Brief History of China Traditional Hospitals**

The Chinese traditional medical care has existed for centuries, since 500 BCE (Renshaw, 2005). However, Chinese traditional medical space is quite different compared to the Western medical space, due to their dissimilar concepts of healing. For Chinese traditional medicine, diseases are mainly caused by disorder of the human body as a system. In the Chinese traditional model the best way to treat the disease is to regain the harmony between body and its environment. The resulting medical space has a very close relationship with the natural environment. Natural ventilation and light become key elements in an optimal curing environment in Chinese traditional medicine.

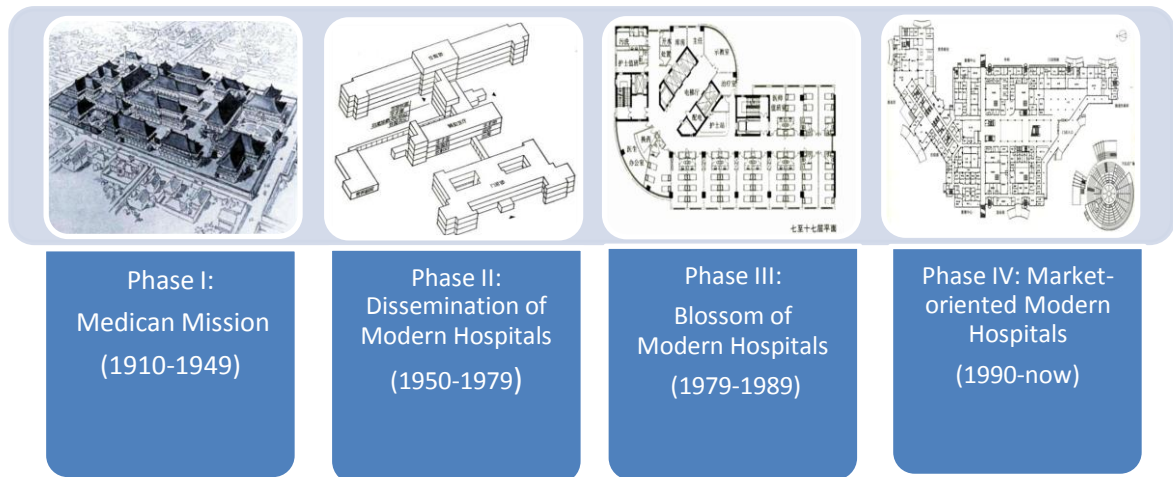
Unlike the isolation and seclusion principle proposed by the Western healthcare, Chinese traditional medical space tends to integrate caring environment with the normal living environment. For instance, most doctors treat the patients in their own houses (See Figure 2.14). The model is similar to what we understand as private clinics today. The inpatient area is very scarce in traditional Chinese medical space. For the very sick patients, most of them would be treated at home if they can afford the payment for doctors' visits. Only very sick and poor patients would stay in the asylums provided by the central authority or religion bodies. Family members always play an important role in assisting the care process.



**Figure 2.14: Timeline of hospital development in China in comparison with The U.S. and European hospitals (Adapted based on Renshaw, 2005).**

## 2.2.2 Four Ages of Chinese Modern Hospitals Development

The highly specialized modern hospitals—facilities that provide surgery and inpatient beds—were brought to mainland China by missionaries in the 1840s (Renshaw, 2005). Since then, Chinese hospitals have experienced great changes in terms of care process, the relationship between patients and caregivers, and the medical space as well. The increase of segregated inpatient area, the gradual shift from natural environment to hybrid HVAC system controlled environment, the focus on the efficiency of traffic, and the enlargement of the distance between doctors and patients, all of the above characterize the changes of Chinese modern hospitals. Based on the degree of Westernization, the Chinese scholar Yulong Liu (2006) classified the modernization of Chinese hospitals into four phases: Phase I: Medical mission (1910-1940); Phase II: Dissemination (1950-1970); Phase III: Blossom of modern hospital (1980-1990); Phase IV: Market-oriented modern hospital (1990-now) (Figure 2.15).



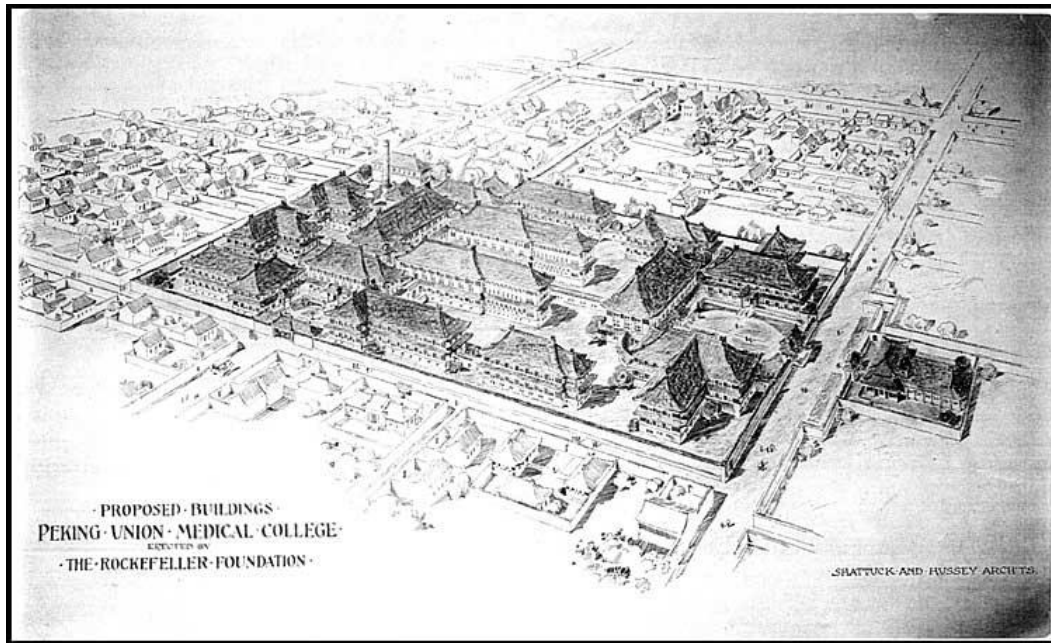
**Figure 2.15: Four phases of Chinese modern hospital development (based on Liu, 2006)**

#### 2.2.2.1 Phase I: Medical mission (1910-40)

The first phase is characterized by the introduction of Western medicine and hospitals through missionaries. The representative examples are Shanghai Renji Hospital built in 1844 and Peking Union Medical College (PUMC) built in 1921 (Liu, 2006). Most of the hospitals built during the first phase adopted pavilion style for the spatial layout. Nightingale ward was widely applied for most of the patient ward designs. In terms of architectural style, many hospitals used the traditional Chinese architectural language to fit into the local environment (Liu, 2006). The purpose for this was to avoid the sense of alien and try to attract local people. One of the most representative examples of this phase is the Peking Union Medical College (Figure 2.16). The designer, an American architect Charles A. Coolidge, intentionally utilized the style representing Chinese traditional palace. “[the buildings] thus symbolize the purpose to make the College not something foreign to China’s best ideals and aspirations, but an organism which will become part of a developing Chinese civilization.” (Rockfeller, 1917, p. 224)



According to Bullock (1980) , PUMC stood both as tribute to the durability of Chinese culture and as monument to an American effort to change it. It seems that from the very beginning, there is a clear tendency to design Chinese hospital as a hybrid between the Western care model and the Chinese culture. The hospital is still in use today and is among the best hospitals in China (Figure 2.17).



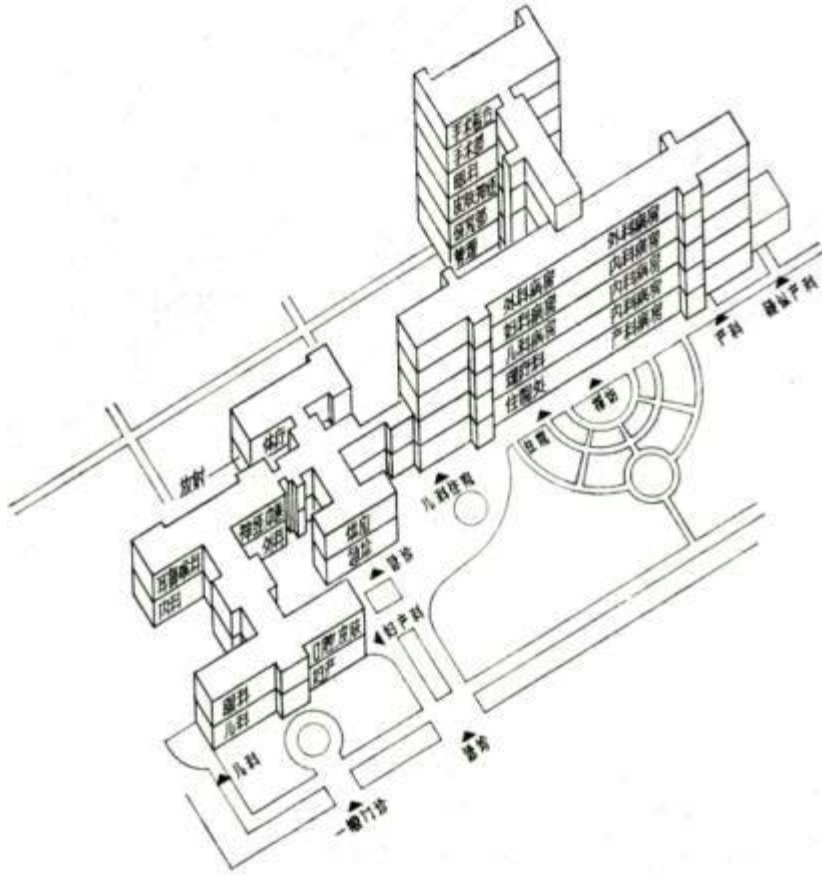
**Figure 2.16: Peking Union Medical College, Perspective by Hussey, Source: China Medical Board Third Annual Report, January 1-December 31, 1919, Folder 68-69 (Rockefeller Archive Center & CMB/PUMC, 1919).**



**Figure 2.17: Peking Union Medical College (photo taken by author).**

#### 2.2.2.2 Phase II: Dissemination (1950-1970)

Between 1950 and 1970, there was big gap in between first decade and second decade due to the “cultural revolution.” During the first ten years, some large hospitals were built in several cities. After the “cultural revolution,” the development of rural clinics was put at higher priority (Ito, 1937). In rural areas traditionally health care was sometimes provided by “barefoot doctors.” There was very limited construction of urban hospitals. This was mostly due to the country’s economic hardship (Liu, 2006). The hospitals built during this phase are mostly functional orientated (Figure 2.18). Most of them were built with patient rooms and support area around center- corridor. In order to allow maximum natural light and ventilation, courtyards are widely applied in the hospital layout.



**Figure 2.18: The Third Affiliated Hospital of Beijing University, (Source: Liu, 2006, p.141).**

#### 2.2.2.3 Phase III: Blossom of modern hospital (1980)

With the migration of population to cities after death of Chairman Mao and the end of the Cultural Revolution, the focus shifted to developing modern urban hospitals. The scale and size of hospitals increase to 500-600 beds. Driven by considerations for efficiency and economy, these urban hospitals provided western care and generally adopted modernist international architectural styles. Due to the concerns regarding the efficiency of circulation, increasing resources have been invested in the explorations of various nursing unit typologies, such as racetrack, W-shape, honeycomb, triangle-shape, etc. The designs are mostly physical and equipment-oriented (Liu, 2006).

#### 2.2.2.4 Phase IV: Market-oriented modern hospital (1990-now)

Following the opening of the market-oriented economy in the early 1990s, Chinese hospitals moved into a market-oriented phase where hospitals competed for a market share, and their facilities have become part of their marketing strategy (Liu, 2006). The scale of those new constructions and renovations is huge, mostly over 1,000 beds, sometime contemplating as many as 4,000 beds. Greater influences from Western countries are witnessed in contemporary China hospitals' design, due to local designers' increased exposure to latest design trends and growing collaboration with international design firms (Figure 2.19) (Liu, 2006). Western firms are mostly involved in programming, consultation services, and early schematic design in preparation for competitions. However, the design development and contract documents are still completed by Chinese firms. The duration for the whole process from feasibility study to occupancy is about 3 years, sometimes as fast as 1-1/2 years. The process is very intense given the length is only a fraction of average duration of the U.S. processes, often 3-6 years or more. The extremely tight design and build schedule poses as a great challenge for in-depth research and programming during the design process.

During this phase, the hospital design is more westernized in the form and design elements. However, there are still intrinsic factors that make Chinese hospital unique. As Liu (2006) has pointed out, the application of innovative Western design concepts in Chinese modern hospitals should well consider Chinese local contextual conditions. We will discuss those including the insurance policies, funding resources, patient profiles, staffing models, culture and care philosophy that impact Chinese hospital design.



**Figure 2.19: Shanghai International Medical City (Designed by Gresham, Smith & Partners, image courtesy: Gresham, Smith & Partners).**

### **2.2.3 Contextual Issues that Impacts Chinese Hospital Designs**

#### **2.2.3.1 Insurance Policy**

The healthcare insurance policies in China have experienced three major reforms since the new government of People's Republic of China (PRC) started in 1949. The current insurance policies are the result of reflection on the previous policies. It contains four schemes. The coverage of services and the proportion of out-of-pocket expense of the total cost vary widely across the four schemes: new rural cooperative medical system, urban employment-based basic medical insurance scheme, urban-resident scheme, and medical assistance program accordingly (Hu et al., 2008). The new rural cooperative medical system is based on the original rural cooperative medical insurance, which targets at the rural population. By the end of 2007, it has covered has resulted in coverage of 720 million agricultural households (85.9% of the total rural population). Funding of the new rural cooperative medical insurance is shared between voluntary participants, the local authorities and the central government. For instance, in the western and middle

regions of China, central and local governments contribute 40 Renminbi (about \$5) for each participant each year, and participants contribute the remaining 20 Renminbi (about \$2.5) (Hu, et al., 2008). The employment-based basic medical insurance scheme was established by the Chinese State Council by the end of 1998. It covers the urban workers with a pooled fund for inpatient stays and individual medical savings accounts for outpatient visits. In 2006, about 160 million people, some 28% of total urban population were covered by the scheme. In 2007, an urban-resident scheme was started to cover other urban residents who were not covered by the urban employment-based insurance, for instance, children, students, and migrants. In addition, a new medical assistance scheme, paid by central and provincial governments, has recently been introduced to the poorest of urban and rural families to cover the expense of serious illnesses (Hu, et al., 2008).

The insurance plans are significantly broadening access to care but are putting financial pressures on operating costs. Government plans require 10% to 50% co-payments by the individual, with the remainder being covered by the local, provincial and central governments. Individuals also have substantial additional out-of-pocket costs for additional procedures and pharmaceuticals. Costs are set by the government, which sets comparatively low prices for common procedures. For instance, an inpatient stay in a three-bed patient room is currently set at 40RMB (about \$5.97) per night. The cost for one infusion—a common way to receive drugs in China—is 5RMB (about \$0.75). As a result, hospitals, hospital departments and practitioners often make up for low base rates by prescribing drugs and expensive tests/procedures that are billed separately (Fairclough, 2009). In addition, it is not uncommon to hospitalize patients who could be appropriately seen on an outpatient basis for inpatient care and prolong their hospital stays for revenue (Hu, et al., 2008).

#### 2.2.3.2 Funding

As with other systems, planning and design of Chinese healthcare facilities are driven by the ways projects and care are funded. As of 2008, 80.3% of the 19,612 Chinese hospitals, and about 90% of beds, were public and directed by government at the city, regional, provincial, national level or by the military (Center for Statistics Information, 2009). While recent central government investment has been aimed towards the highest level (level 3 or *sanjia* in Chinese) hospitals in the largest cities, called “Tier 1” cities, the central government is increasingly investing in level 2 and level 1 hospitals in smaller Tier 2 and Tier 3 cities. Also, with growing affluence and international impact, China is rapidly developing private hospitals and VIP services in some public hospitals.

Although in most cases the government partially supports the initial construction cost, most hospitals still have to apply for loans in order to cover the rest of construction cost. In addition, hospitals have to operate as independent entities with limited financial support from the government. Therefore, how to control the long-term running cost becomes a key concern of public hospital CEOs and a challenge for designers.

#### 2.2.3.3 Patient Profiles

Due to the pressures to increase capacity and keep costs low, most new hospitals have patient rooms with 2-4 beds, and a few have 6 beds. The space standards are much smaller than the U.S. hospitals. However, for VIP buildings or VIP floor often provide single patient rooms, or even single patient suites.

Unlike the U.S. and most Western health systems, currently in China basic health insurance has no clear guidelines on length of stay. Also, there are few facilities to accept patients who are not able to go home, such as rehabilitation facilities or long-term acute care. The consequence is that Chinese hospitals have longer lengths of stay when



compared to the U.S. standards, often 10-18 days (Center for Statistics Information, 2009) . Most inpatient units have high patient beds utilization rate as well. In Beijing, the average stay days are 15.0 and the utilization rate of patient beds is 83%. In Shanghai, the average stay days are 15.5 days and the utilization rate of patient beds is 99.5% (Center for Statistics Information, 2009). In addition, patients in inpatient facilities have a wide range of level of acuity. Whereas some are quite ill, many Chinese inpatients are able to walk around and receive rehabilitation as part of their inpatient stay.

#### 2.2.3.4 Staffing

The low reimbursement rates and limited staffing in China hospitals emphasize designs that allow hospitals to operate efficiently with high patient-to-staff ratios. High patient-to-staff ratios are also driven by availability of trained staff, especially of nurses. For example, whereas in 2008 China had about 37% of the U.S. rate of doctors per capita (1.5 doctors per 1,000 people versus 4.2 doctors per 1,000 in the U.S.), China had only 10% as many nurses (1 per 1,000 versus 9.4 per 1,000 people). In the U.S. hospitals there are typically 4-8 patients per nurse for an inpatient medical-surgical floor. In China it is not unusual to have a 10-1 patient-to-nurse ratio during day shifts, and 12-1 or higher during night shifts. As a consequence, nursing work is often organized by task such as medication administration rather than having patients assigned to individual nurses. The heavy workload and low payment/reward system pose challenges to staff recruitment and retention. The designs of nursing units also have to consider carefully shortening nurses' walking distance, increasing nurses work efficiency, and improving impromptu communication to facilitate task handover and care team collaboration.

#### 2.2.3.5 Healing Philosophy and *Fengshui* Theory

The belief in *Fengshui* principles also has strong implications in Chinese hospital design. Based on *Fengshui* theory, human beings can ensure the well being by keeping a



harmonious relationship with nature, through identifying a good location for human settlement and acting according to the nature (Li, 2002). Facing south is believed to be related to the channeling of the positive flow of *Qi (the life energy)*, therefore can help patients heal faster. The south orientation also has practical meaning. In China most area belonged to continental climate, it is warm in summer and cold in winter. The selection of south orientation is preferred in design for the benefits of longer sunlight. As a result, most patient rooms are designed to face south. The “2004 Edition of Architectural and Design Code for Chinese General Hospitals” clearly defines that more than half of patient rooms should have optimal (southern) sunlight and natural view (Ministry of Housing and Urban-Rural Development of the People's Republic of China [MOHURD] , General Administration of Quality Supervision Inspection and Quarantine of the PRC [AQSIQ], & Health Care Architecture Design Committee of Association of Chinese Health Economics, 2004b).

In addition, due to both economical considerations and the belief in natural ventilation as a healing factor, the design of Chinese inpatient units focuses on making the best use of natural ventilation. As a result, even though HVAC systems are installed in most Chinese hospitals, the HVAC is only in active operation for about 1/3-1/2 of the year. Most hospitals still apply the hybrid model of ventilation, in other words, even if they have the HVAC on, they will still open the windows every week or at least every 10 days to allow the outside “fresh” air circulate in the units.

#### **2.2.4 Chinese Nursing Unit Typologies**

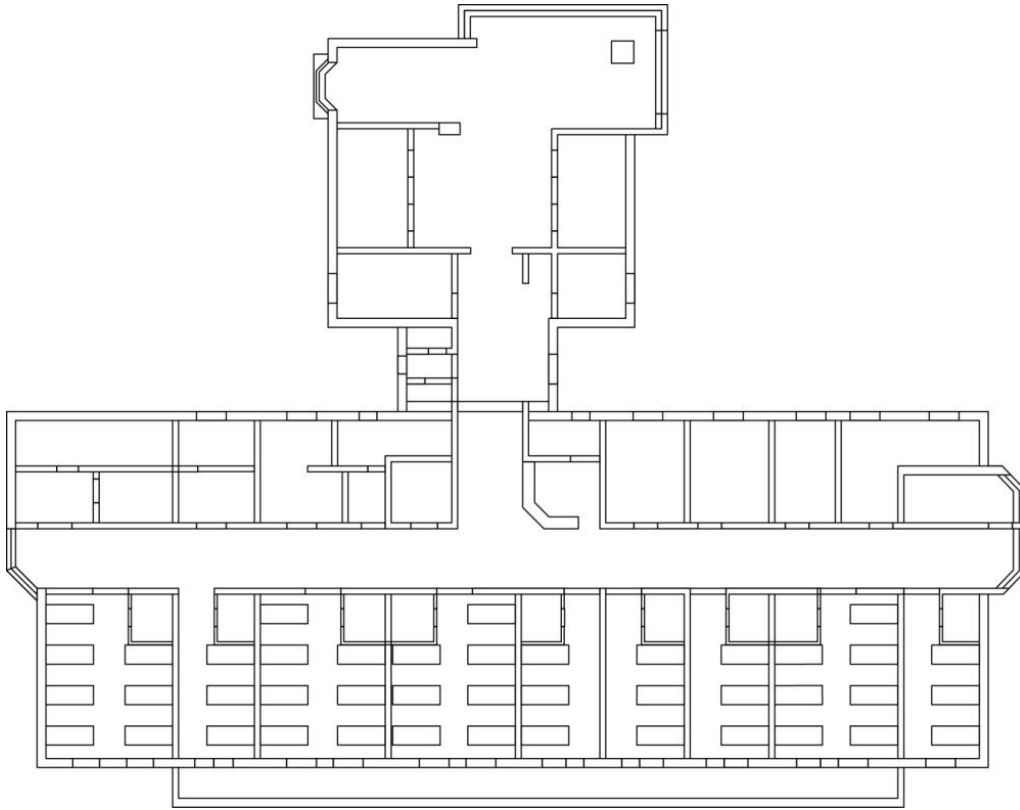
The resulted Chinese nursing unit designs seem to present some unique characteristics. A detailed review of Chinese nursing unit typologies is provided below.

#### 2.2.4.1 Single Corridor

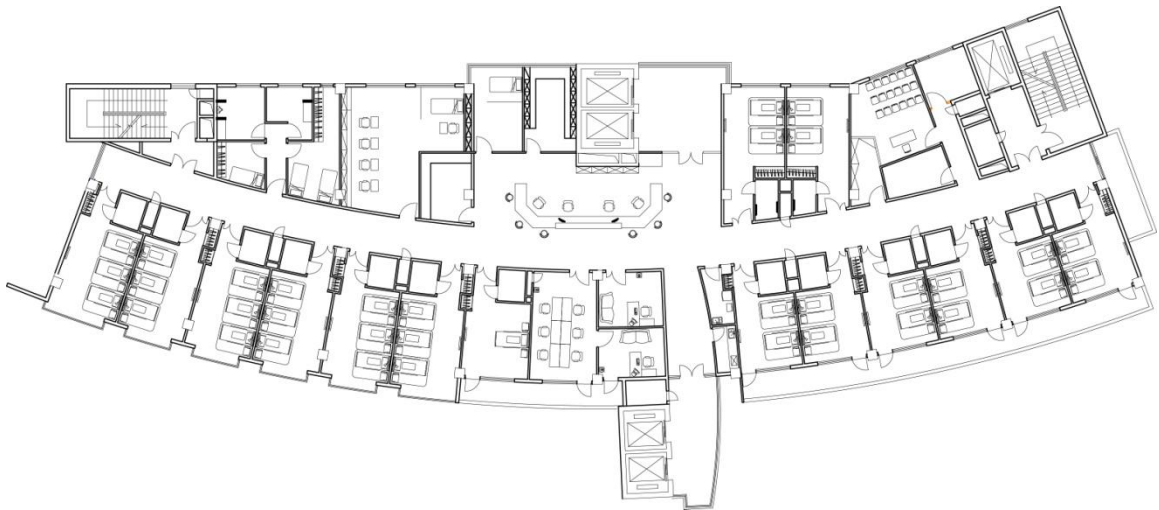
Single corridor layout is one of the most popular typologies in Chinese inpatient units. It is due to several reasons. Before economy reform because of low initial investment, there is no HVAC system in most hospitals. Single corridor layout was most popular due to the ease of access to natural ventilation and light. Since 1980, the improvement of Chinese economical condition made it possible for the equipment of HVAC system in Chinese hospitals, which led to the possibility of exploring other typologies. However in 2003, with SARS hit China with a shock, single corridor regained its status, because of its strength in ease of natural ventilation and light.

For most single corridor layouts in China, patient rooms are arranged along the southern side of the building, with a corridor that separates the patient zone from the caregivers' work zone. For example, the Shanghai Huashan Hospital No.2 inpatient building is based on a T-shape plan with all patient rooms placed on the southern side of the building, the staffs support area arranged on the northern side, and the vertical circulation attached perpendicularly to the main corridor (Figure 2.20).

To ensure that as many patient beds as possible can have southern sunlight, some designs apply curve shape on the south façade to accommodate more patient rooms. Shenzhen Eye Hospital Inpatient unit is such an example (Figure 2.21). All patient rooms are arranged along the curve-shaped southern wall to receive sunlight. The nurse station is placed at the middle of the northern side to provide maximum visual surveillance towards patient rooms.



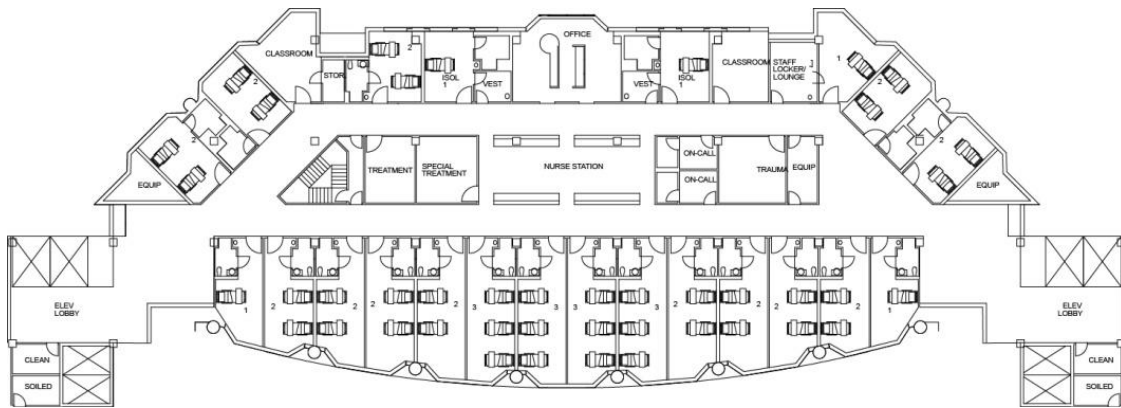
**Figure 2.20: Shanghai Huashan Hospital No.2 Inpatient Building (drawn by author).**



**Figure 2.21: Shenzhen Eye Hospital Inpatient Unit, (source: Gresham Smith & Partners).**

#### 2.2.4.2 Racetrack

Racetrack layout has increasingly become a popular layout in Chinese nursing unit design, mostly due to its circulation efficiency. As shown in the case of the Shanghai First People's Hospital, a racetrack loop circulation theme is adopted in the design. An open nurse station sits in the middle of the layout to maximize visual surveillance towards patient rooms and reduce walking distances. Some direct staff support areas such as treatment rooms and equipment rooms are placed in the central core near the nurse station. Other staff support areas are located on the northern side of the unit, while most of patient rooms are arranged on the southern side (Figure 2.22).

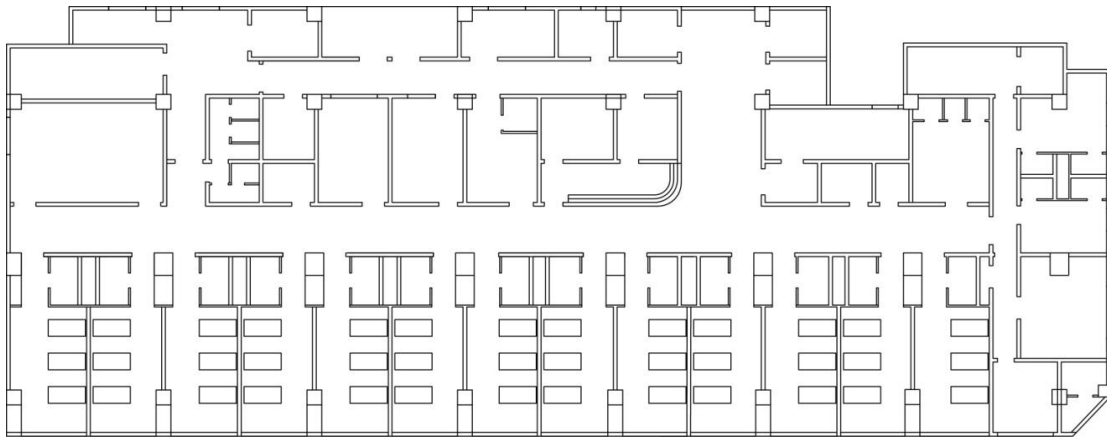


**Figure 2.22: Shanghai First People's Hospital, (source: Gresham, Smith & Groups).**

#### 2.2.4.3 Mutated Racetrack

A unique nursing unit typology that has been very popular in China is the mutated racetrack layout. The main difference between the mutated racetrack and the typical racetrack is the separation between the main public corridor and service corridor in the mutated racetrack layout. As in the case of Ruijin Hospital No.6 inpatient building (Figure 2.23), the main public corridor divides the patient zone on the south from the staff zone on the north. A service corridor is connected with the main public corridor as a loop circulation system. However the use of the service corridor is reserved for caregivers. As a result, the mutated racetrack layout has the benefits of the efficiency of

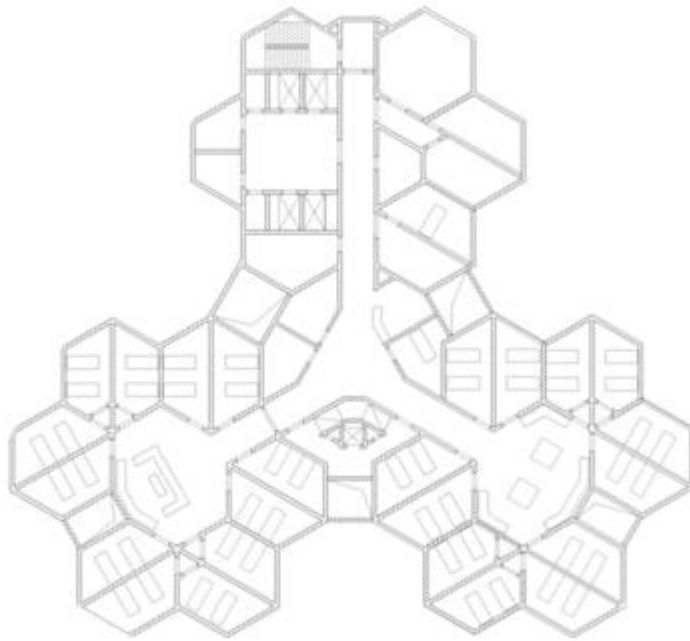
caregivers' movement (as two-way traffic), and the ease of control of patients' and visitors' movement (as one-way traffic). In addition, some private functions such as on-duty rooms and a conference room are arranged on the eastern side of the unit, separating from the main circulation with a small internal corridor. More interestingly, the office of the unit director is located at the most remote southeastern corner of the unit. The layout demonstrates a clear distinction of public versus private spaces.



**Figure 2.23: Shanghai Ruijin Hospital No.9 Inpatient Building (drawn by author).**

#### 2.2.4.4 Cluster/cruciform

Cluster/cruciform layout is very rare in Chinese inpatient unit design. The reason might be that the current task-based care model and low nurse to patient ratio in China does not support the cluster design that separates nurses into small teams. Chengdu Traditional Chinese Medicine Hospital is one of the few examples that we found to apply the cluster typology. It is based on a honeycomb layout, with three clusters each formed by six honeycombs. Two clusters are for patient zone, with a nurse base in the middle of the cluster. The third cluster is composed of the staff support zone, the elevator lobby and the staircase. The design is quite efficient, as each floor can accommodate 50 patient beds (25 beds per cluster) and the area per bed is only around 22m<sup>2</sup>.

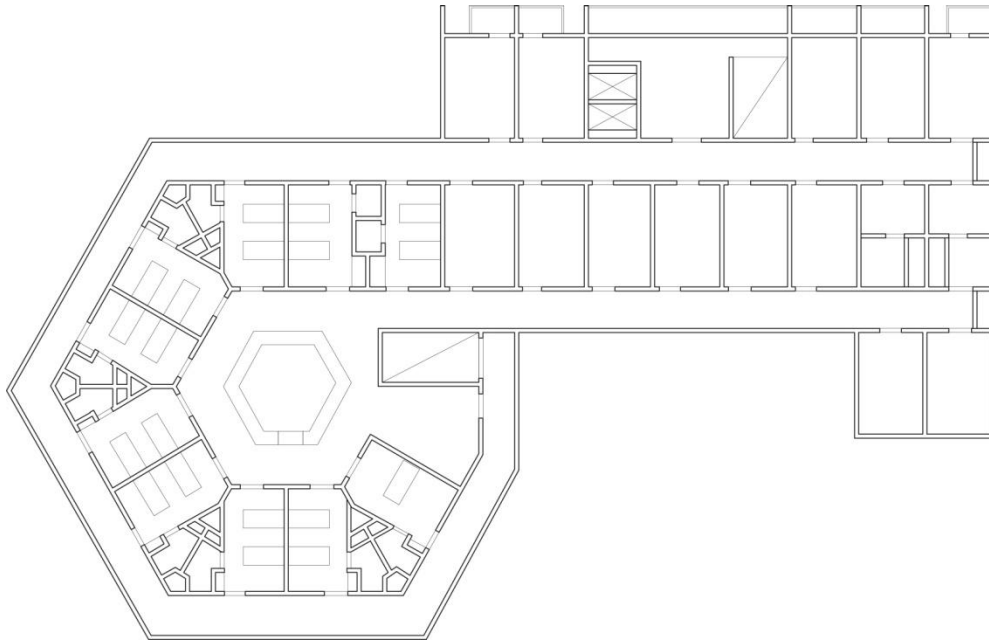


**Figure 2.24: Chengdu TCM Hospital, (Source: Luo, 2001, p. 167).**

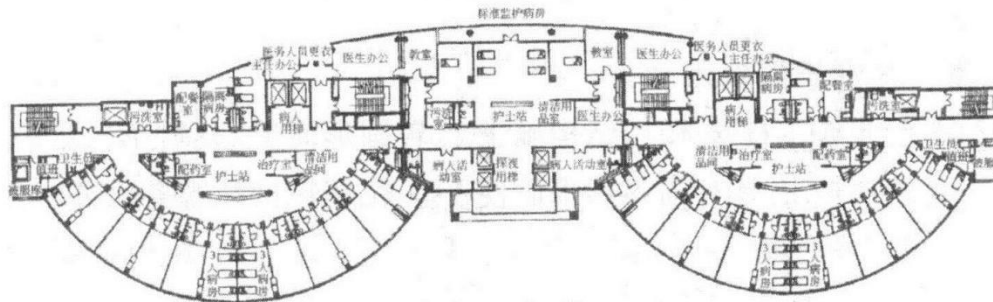
#### 2.2.4.5 Radial

Full radial layout of nursing unit is also rare in China, due to the high demands for patient rooms with the southern sunlight. One example is the Chongqin Southwestern Hospital Burns Unit (Figure 2.25). The patient rooms are arranged around a hexagon, with a nurse station in the middle. The staff zone is designed as a long rectangle attached to the side of the hexagon patient zone. These two zones are connected with both an external corridor and an internal corridor that wrap around patient rooms.

More common examples of radial layouts in China are based on fan-shape or quarter-radial shape. For example, the Shanghai Eastern Hospital inpatient unit is a hybrid of a half-radial and racetrack. The patient rooms are located on the south side along the half-radial curve. The nurse station is located in the center to monitor most patient rooms. The staff support area is located on the north side and separated from the patient zone and nursing base with a long corridor (Figure 2.26).



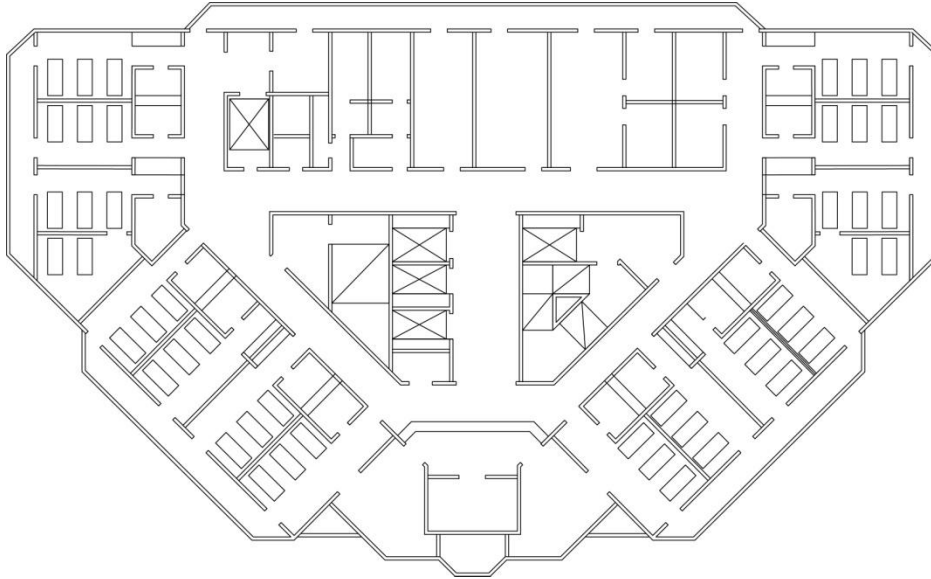
**Figure 2.25: Chongqin Southwestern Hospital Burns Unit, (Source: Luo, 2001, p.160).**



**Figure 2.26: Shanghai Eastern Hospital Inpatient Unit, (Source: Luo, 2001, p. 161).**

#### 2.2.4.6 Triangular

Triangular layout has been applied in some cases, yet not popular in China. Usually the patient rooms take two sides that are facing south, and the staff zone takes the other side of the triangle. As in the case of Sichuan Third People's Hospital (Figure 2.27), the core of the triangular unit is occupied by the elevators and stairs. The nurse station is placed in-between the joint of two wings of patient rooms, to provide surveillance towards the circulation area. The caregivers' support zone is located on the northern side of the unit, facing the nurse station, to ensure short walking distance in retrieving supplies.



**Figure 2.27: Sichuan Third People's Hospital Inpatient Unit, source: (Du, 2004).**

### **2.2.5 A Survey of Chinese Nursing Unit Typologies during 1989-2008**

In order to understand the application of various typologies in China, we further conducted a large scale survey on Chinese nursing unit design. The sources of the survey were three key publications in Chinese hospital design: “The Selected Works of China Hospital Architecture Series 2 (1989-1999),” (Division of Planning and Finance/MOH & CHEA/AHA, 1999) “The Selected Works of China Hospital Architecture Series 3 (1999-2004),” (CHEA/AHA & CIA/AHA, 2004) and “The 2008 Collection of Good Chinese Hospital Building Designs.” (Lv, 2008) These three books have assembled best practices examples sampling from all provinces and cities in China. Each best practice example was provided with a brief introduction of the case, the design intent, and innovative design features. These three books covered a wide variety of hospital design classified per periods of time in different regions of China, thus provided us a valuable resource for our research. In total, there were 116 nursing unit floor plans available. We categorize them based on the time period and the nursing unit typologies they apply. The results help to depict the pattern of distribution of different nursing unit typologies and the trend of nursing unit typology transformation in China over the last 20 years (Table 2.1). Fifty-

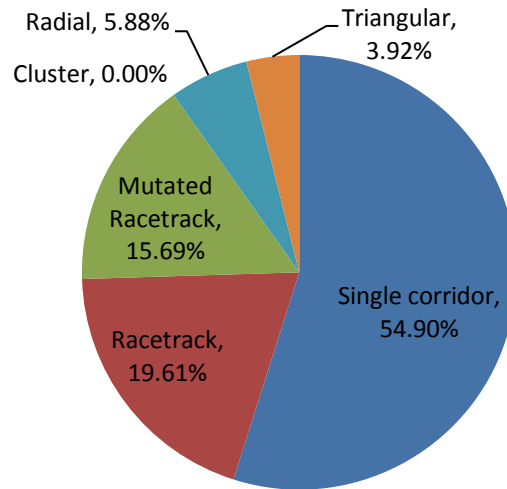


one nursing unit floor plans were provided for the collections from 1989 to 1999. Among them, 54.9 percent were single corridor layouts, 15.69 percent were mutated racetrack layouts, 9.61 percent were racetrack layout, 5.88 percent were radial layouts, 3.92 percent were triangular layouts, and no cluster layouts. Among the 54 floor plans from 1999 to 2004, 35.19 percent were mutated racetrack layouts, 33.33 percent were single corridor layouts, 14.81 percent were racetrack layouts, 9.26 percent were radial layouts, 5.56 percent were triangular layouts, and 1.85 percent were cluster layouts. In 2008, among 11 cases, racetrack layouts accounts for the largest percentage (36.36%), followed by single corridor layouts (27.27%) and mutated racetrack layouts (27.27%), radial layout (18.18%), triangular layouts (9.09%), and cluster layout (0%) (Figure 2.28, Figure 2.29, Figure 2.30).

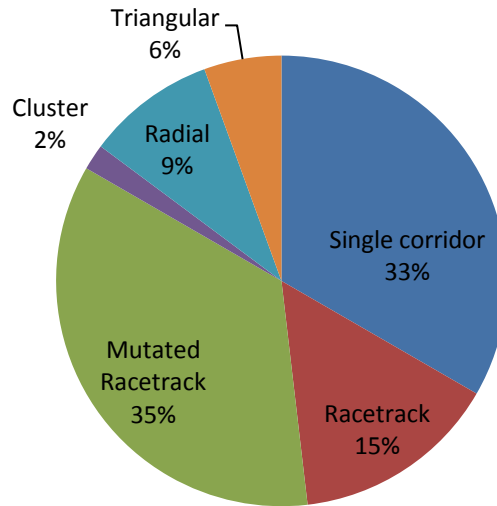
The results demonstrate that Chinese nursing unit designs present unbalanced development on various typologies. Single corridor layout is one of the most popular typologies in China inpatient units. During 1989-1999, more than half of the collection of best practices is based on single corridor layout. During the period covering 1999-2008, the percentage of single corridor layout reduces yet still accounts as a majority of nursing unit design. Racetrack and mutated racetrack layouts have become more and more popular in China. More than 60% of designs apply either racetrack or mutated racetrack in 2008. Although there are increasing interests in exploring other typologies such as triangular, radial, and cluster layouts, the practices on these typologies are still comparatively rare in China. To the extent of the author's knowledge, there is no example of distributed layout that has been applied in China.

**Table 2.1: A Survey of Chinese Nursing Unit Typologies during 1989-2008**

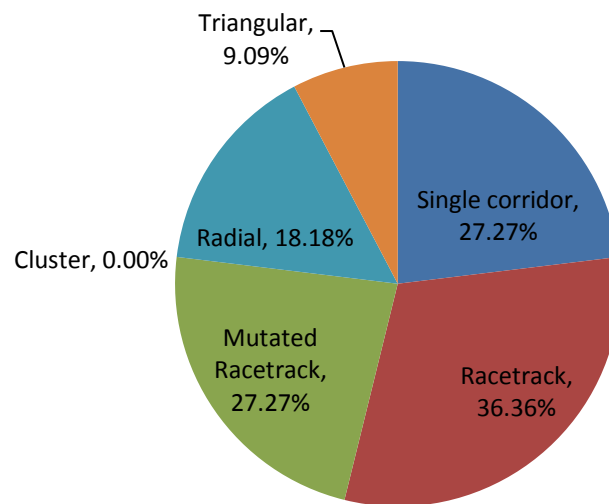
Phase		Single corridor	Racetrack	Mutated Racetrack	Cluster	Radial	Triangular	Total
1989 - 1999	Number	28	10	8	0	3	2	51
	Percentage	54.90%	9.61%	15.69%	0.00%	5.88%	3.92%	100%
1999 - 2004	Number	18	8	19	1	5	3	54
	Percentage	33.33%	14.81%	35.19%	1.85%	9.26%	5.56%	100%
2008	Number	3	4	3	0	2	1	11
	Percentage	27.27%	36.36%	27.27%	0.00%	18.18%	9.09%	100%



**Figure 2.28: Distribution of nursing unit typologies in China during 1989-1999.**



**Figure 2.29: Distribution of nursing unit typologies in China during 1999-2004.**



**Figure 2.30: Distribution of nursing unit typologies in China during 2008.**

The descriptions of Chinese nursing unit typologies and the applications of various typologies in China indicate that culture factors have a level of impacts on nursing unit designs. More careful comparisons between Chinese and The U.S. nursing unit designs are necessary to examine if there are consistent reflections of cultural differences on design. However, little research has done to evaluate the cultural aspects of nursing unit designs.

### **2.3 Previous Research on Nursing Unit Design**

Existing research on nursing unit design showed an unbalanced development of interests. Most studies focus on efficiency of nursing units like nurse walking distances, time spent on walking and visibility towards patient rooms (Shepley & Davies, 2003; Sturdavant, 1960; Trites, Galbraith, Sturdavant, & Leckwart, 1970). For instance, Sturdavant (1960) compared two intensive care units at Rochester Methodist Hospital in Minnesota, one with radial design and the other with a single-corridor design. By increasing visual surveillance of patients from the nurse station and reducing the time spent on walking, the radial design was found to be more efficient than the single-corridor design. Later Trites and his colleagues (1970) further compared three unit designs: radial, single-corridor (L-shaped) and double-corridor (racetrack). The behavior and perception data confirmed that radial designs were more successful than double-corridor and single-corridor designs. In radial designs, nurses traveled less and the teamwork was perceived to be more effective. Similarly, Shepley and Davies (2003) compared a radial configuration to a double-corridor rectangular floor plan. They found that nursing staff in the radial design walked significantly less than staff in the rectangular unit (1.97 miles per segment vs. 6.87 miles per segment). Gurascio-Howard and Malloch (2007) suggested that unit design, room assignments, patient acuity, team interaction, and tasks all have an impact on RN movement. Similarly, Hendrich et al. (2009) pointed out that nurses adjusted their movement based on the room assignment and care model.

To cross-compare the efficiency of different nursing units design, several scholars have proposed various efficiency measures. The famous Yale Traffic Index is an interesting example that links care model and caregivers' behavior with the walking efficiency (Thompson & Goldin, 1975). In order to generate reliable criteria to evaluate the functional efficiency, John Thompson and Robert Pelletier designed a six-month

study in two surgical and two medical units. They recorded all the trips during 12 non-consecutive shifts, 3 each for 4 different inpatient units, and a second set of 3 for one of the units to double check the results. The trip information they recorded includes who, where to/from and when of each traffic route. They found the 14 links that were most important and the most frequent traffic routes (Table 2.2). Among 14 links, patient room to patient room is the top one traffic route. The second is from nurse station to patient room. Nursing traffic accounts for 70.3 percent of total traffic. Based on the relationship between the distances between areas, the relative number of times the distance is traversed and the number of patients cared for, the researchers came up the formula for the Yale Traffic Index. Mathematically, it multiplies the minimum average distance between rooms by the sum of the percentage of trips, then divide by number of patients. The authors used the Yale Traffic Index to evaluate 30 American nursing unit plans. They discovered that the design of the nursing unit is the most crucial factor in determining the efficiency of the unit. They found that most compound circulation based layouts are more efficient than simple circulation based layouts. In more detail, the radial layout is more efficient than double corridor, and double corridor is usually more efficient than single corridor.

The Yale Traffic Index has been applied in many American hospitals for the purpose of efficiency evaluation. However, later researchers found that the Yale Traffic Index has a limitation, since it is highly impacted by the care model, supply model, and culture. For instance, for nursing units with a central supply system, the frequency of using utility rooms decreases dramatically. A recent study by Hendrich and colleagues showed that the design of decentralized location of supplies helped dramatically reducing walking and supply trips (Hendrich, Fay, & Sorrells, 2004) .

James and Tatton Brown (1986) returned to use the commonly accepted efficiency measures to compare units, the average distance from the nurse station to

patient beds, the number of beds per 10 feet running of corridor, and area per bed. By using the same mathematical criterion to compare open ward, corridor, racetrack, courtyard, cruciform and radial layout, they found that open wards and radial plans have smaller average distance from nurse station to beds than courtyard and racetrack plans. Cruciform and courtyard plans are more compact and efficient than racetrack and radial plans, since they have higher the number of beds per 10 feet running of corridor. The racetrack plan is less economical in space use than cruciform plan and open ward. They also pointed out that in addition to three common efficiency indexes, the visibility from nurse station to patient rooms and the visibility between nurses and patients along the nurses' journeys are very important.

**Table 2.2: 14 major links identified in the Yale Traffic Study (Thompson & Goldin, 1975).**

<b>14 Major Links in the Yale Traffic Study</b>		
Rank	Percentage of Traffic (%)	The points of Connection
1	19.1	PR-PR
2	16.7	N-PR
3	14.1	U-PR
4	9.8	N-U
5	6.1	N-E
6	5.8	N-M
7	4.6	PR-P
8	3.7	PR-E
9	3.2	M-PR
10	2.5	U-E
11	1.8	U-M
12	1.7	U-P
13	1.1	U-J
14	1.0	N-P

**\*PR (patient room), N (nurses' station), U (utility room), E (elevator lobby), M (medication closet), P (pantry), J (janitor's closet).**

## **2.4 Summary**

This chapter has examined the historical evolution of nursing unit typologies in both the Western context and in China. Some key factors were identified as main drivers for nursing unit design: staff efficiency, space economy, and access to natural light. In addition, it was speculated that cultural context plays a role in nursing unit design, because descriptions of Chinese nursing unit typologies and the application of various typologies in China seem to exhibit some uniquely Chinese characteristics when compared to those from Western countries. Some background issues that pertain to Chinese nursing unit design are discussed, such as insurance policies, funding, and patient profiles, staffing, and care philosophies.

This chapter also reviews existing studies on nursing unit typologies. The review identifies key metrics that will be used to evaluate the space economy and staff efficiency of nursing unit layouts later in this study. More importantly, the review reveals the need for examining cultural impacts on nursing unit design, and especially the need for addressing the link between culture, communication and nursing unit typologies. So far, no in-depth studies have been done that explore the cultural impacts on nursing units design and examine how designs might reflect the cultural needs of users. The particular cultural needs under consideration in this study focused on communicational needs. The next chapter discusses the importance of communication in the healthcare environment. It is followed by a discussion of the cultural properties of communication in Chinese nursing units in Chapter 4.

## **CHAPTER 3**

### **FACE-TO-FACE INFORMAL COMMUNICATION IN HOSPITALS**

This chapter reviews the research evidence about the role of face-to-face, informal communication in health care settings, focusing particularly upon such communication that occurs in inpatient healthcare units. The first section outlines the importance of communication in improving care team collaboration, healthcare delivery, and even learning and innovation. The second part clarifies how face-to-face interactions are the most important mode of communication in the healthcare settings. The third part of this chapter explores the characteristics of hospital space that encourage the multi-disciplinary care team's communication.

#### **3.1 Communication in Healthcare Environment**

Communication in healthcare settings has long been recognized as important. First of all, it helps mitigating initial perceptions of stressful work situations, offloading the stress from work (House & Wells, 1978). In the Nursing Stress Scale proposed by Gray-Toft and Anderson (1981), the lack of support and communication is identified as one of the main factors contributing to nursing stress. Based on a survey on 10,022 nurses in 32 hospitals in England, Rafferty, Ball, and Aiken (2001) found that nurses with a higher interdisciplinary teamwork score were more satisfied with their jobs, planned to stay in them, and were likely to have a lower burnout score. Communication is also helpful to create friendly atmosphere in the work place. The number and quality of one's friendships are good predictors of individual and organizational health, work performance (Cooper, 1973), and one's overall satisfaction (Craik & Zube, 1976).

In addition, communication is imperative in strengthening teamwork and overall healthcare delivery (Wood, Farrow, & Elliot, 1994). Health delivery processes involve caregivers from multiple healthcare professions. According to O'Daniel and Rosenstein



(2008), during the course of a 4-day hospital stay, the care for one patient may involve 50 different employees, including physicians, nurses, technicians and other medical support staff. Communication plays an important role in forming multidisciplinary teams and sustaining themselves.

More importantly, communication has direct and indirect impacts on patient outcomes (e.g., Baggs et al., 1999; Knaus, Draper, Wanger, & Zimmerman, 1986). In a study of 5,030 patients in 12 ICUs, Knaus and his colleagues (1986) found that collaboration among caregivers was the strongest factor contributing to observed differences in patient outcomes. Failed communication among individuals and poorly coordinated team are identified as major contributors to errors (Andrews et al., 1997; Buerhaus, 2001). Health care practitioners from different disciplines have to constantly communicate patient information with each other to prevent replication of efforts and medical errors (McCarthy & Blumenthal, 2006). Growing evidence indicates that inadequate communication processes among members of health care teams can substantially rise clinical mishaps even mortality (Coiera, 2000; Kohn, Corrigan, & Donaldson, 2000). Instead of inadequate medical skills, communication problems were found to be the most common cause of preventable disability or death (Coiera & Tombs, 1998). Several empirical studies have also shown that a higher degree of involvement and interactions among caregivers lead to a lower risk of negative outcomes (Baggs, et al., 1999) and a shorter risk-adjusted length of stay (Shortell et al., 1994). In the integrated nursing care delivery model, communication and collaboration between nurses, physicians and support staff is a fundamental part of the flexible care delivery system (Hendrich, et al., 2004). Collaboration based on interdisciplinary care teams correlate with better patient outcomes such as: decreased length of hospital stay (Wieland, Kramer, Waite, & Rubenstein, 1996), increased patient satisfaction (Trella, 1993); and decreased mortality one year after discharge (Wieland, et al., 1996).

Communication also plays an active role in effective organizational learning, which is important for care quality improvement and patient outcome (Mountford & Rogers, 1996). Lave and Wenger (1991) describe organizational learning as engaging the “community of practice.” The knowledge pool is based on the shared repertoire of communal resources (routines, sensibilities, artifacts, vocabulary, styles, etc.) that members have developed over time (Wenger, 1999:73-84). The tacit knowledge transmits and accumulates by engaging in the ‘community of practice’ through communication and collaboration. It is similar to what Hutchins (1995) defines as ‘distributed cognition’. He claims that knowledge may be distributed across the members of a social group and the environmental structure. To construct strong social relationships and to develop the ability to identify and go to the right person who has the specific knowledge is important in gaining a wealth of problem-solving capacity. In that sense, a nursing unit can be viewed as a ‘Community of Practice’, a dynamic knowledge-embedded space (Becker, 2007). The development, storage, distribution, and deployment of professional knowledge and cultural intelligence emerge as the main strategic element in the survival of healthcare organization. Successful communication can enhance the transmission and accumulation of tacit knowledge among the care team. “The best and most cost-effective outcomes for patients and clients are achieved when professionals work together, learn together, engage in clinical audit of outcomes together, and generate innovation to ensure progress in practice and service.” (Borrill et al., 2000: p.27)

### **3.2 Face-to-face Informal Communication in Health Care Settings**

The type of communication in which we focus on in this study is the face-to-face informal communication. Although nowadays communication in healthcare settings are implemented through various media, such as telephone, paging, notes, information boards, “Vocera” (hand-free voice-activated mobile phone) etc., face-to-face communication is still the preferred mode in hospital context. According to Coiera and his colleague’s

(2002) observation on twelve clinical staff members' communication patterns, comprising of six nurses and six doctors in two emergency departments in New South Wales hospitals, face-to-face conversation accounted for 82% of the total communication. Much of this communication is, in fact, informal, unplanned, and opportunistic. Another study conducted in a hospital with a mature computer-based record system demonstrated similar pattern: about 50% of all transactions occur face-to-face between colleagues (Safran, Sands, & Rind, 1999).

One of the main benefits of face-to-face communication over other forms of communication is that it enables and facilitates rapidly information exchange and team coordination (Taylor, 2008). A large amount of health care encounters are very brief interactions that take less than five minutes, and happen across a range of sites in the hospital (Crawford & Brown, 2010). Studies have shown that between 34 and 49 percent of nurses' time were spent on coordination-related activities, while only between 31 and 44 percent on direct patient care (Hendrickson, Doddato, & Kovner, 1990; Lundgren & Segesten, 2008; Minyard, Wall, & Turner, 1986; Quist, 1992). Effective face-to-face communication can enhance nurses' awareness of others' work and help them efficiently coordinate with other care givers (Page, 2004). Face-to-face communication is also preferred as the most information-rich medium (Clark, 1996; O' Conaill, Whittaker, & Wilbur, 1993). Comparing to e-mail or progress notes written in the chart, direct face-to-face communication is more helpful because it is able to clarify misunderstandings, confirm what has been agreed to, and avoid errors (Goldszer, 2004).

### **3.3 Face-to-face Communication and Physical Environment**

Despite the importance of face-to-face communication, differences in professional hierarchies, specification of domains, roles, sex, and ages of different clinicians can present a problem and challenge for effective cross-disciplinary communication and collaboration in contemporary hospitals. Some strategies have been explored to enhance

face-to-face interaction in hospitals. However, most of them focus on organizational management and culture. Only a limited number of studies have examined how physical environment can help improve face-to-face interaction, especially in a multi-disciplinary care team (Becker, 2007; Ellingson, 2002, 2003; Iedema, Long, & Carroll, 2010; Rashid, 2009). Among them, the most important finding is that face-to-face interaction can be affected by controlling the interfaces between clinicians and patients, and among different communities of clinicians. The former interface can be controlled by differentiating the boundary between backstage and frontstage communication. The latter goal, which is to create and support the communities of clinicians, can be achieved through defining the appropriate building programs, or the spatial structure of the interfaces among different categories of clinicians.

### **3.3.1 Backstage and Frontstage Communication in Hospitals**

Goffman (1959) coins the concepts of “frontstages” and “backstages” communication to describe the phenomenon that people adjust their performances in different contexts. Face-to-face communication is highly contextual and situational. Under different social situations, people present various patterns of face-to-face communication. The social situation varies not only based on the age, sex, and social status of people who are involved in the communication, but also based on the attributes of the environment where the communication takes place. For example, a subordinate might feel less comfortable to challenge his/her manager during a formal meeting in a conference room than during an informal conversation over the break room. According to Goffman (1959), frontstage is where performance related information is “in play” while backstage is where suppressed information makes an appearance. Therefore, “frontstage communication” would be more public interaction that is possible to reveal to public. While the “backstage communication” would be more private interaction that is only open to people inside domain.

The definition of “frontstage” and “backstage” is related to the distinction of user groups such as “inhabitants” and “visitors.” Usually the inhabitants are long-term users of the space and have control over the space, while the visitors are the temporary or short-term users of the space. One of the generic functions of buildings is to provide boundaries to maintain the interface between inhabitants and visitors, and to control interactions both within and across different user groups (Hillier & Hanson, 1984).

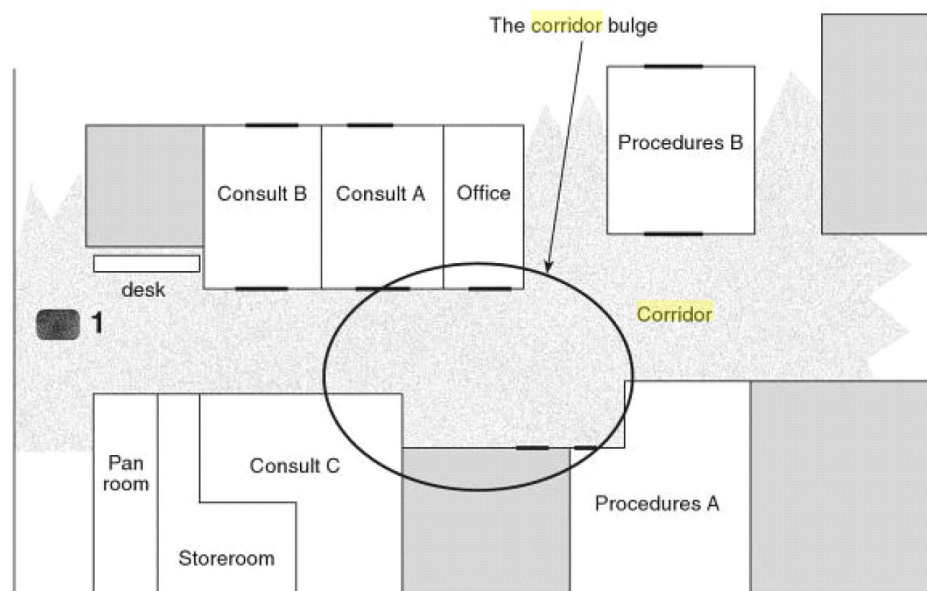
In the context of hospital inpatient units, the inhabitants are caregivers and the visitors are patients and their families. Accordingly, frontstage spaces are usually the spaces that are visually exposed to patients and visitors, such as the lobby, patient rooms, consultation rooms, some part of the nurse station etc. Backstage spaces include spaces where the multi-disciplinary care team has a certain privacy, such as doctor office, meds room, treatment room, supply room, some part of the nurse station etc. The phenomenon of the “frontstage communication” and “backstage communication” in hospitals has been observed in some existing studies (Ellingson, 2002, 2003; Iedema, et al., 2010; Wittenberg-Lyles, CIE’GEE, Oliver, & Demiris, 2009).

In a report on the communication, collaboration and teamwork among healthcare professionals, Ellington (2002) conducted an extensive literature review on multidisciplinary and interdisciplinary health care team communication. She found that cross-disciplinary communication and collaboration was difficult to achieve due to the differences in professional roles, status and gender. She further pointed out that the backstage space such as break rooms, hallways, clinic computer desk and work tables, photocopy rooms, and offices, might provide a good site to blur the boundary between roles and ranks, renegotiate the rigid divisions of the health care hierarchy, thus move the team from a multidisciplinary mode toward a dynamic interdisciplinary or transdisciplinary mode (Ellingson, 2003; Opie, 1997). Here the difference between multidisciplinary, interdisciplinary and transdisciplinary team lies on the degree of

collaboration and integration of knowledge from various disciplines: multidisciplinary teams work independently and parallel to each other with common goals in mind, relying on formal communications to inform each other (Satin, 1994); interdisciplinary teams work interdependently with each other through both formal and informal communication to achieve a higher degree of coordination and integration (Wieland, et al., 1996); transdisciplinary teams have very flexible disciplinary boundaries and engage all team members in teaching and learning across disciplinary boundaries (Wieland, et al., 1996). Based on a long-term ethnographic study on an interdisciplinary geriatric oncology team at a regional cancer center, Ellingson (2003) revealed the importance of backstage communication in enhancing team collaboration. She classified seven categories to describe the communication involved in backstage teamwork in the clinic: “informal impression and information sharing; checking clinic progress; relationship building; space management; training students; handling interruptions; and formal reporting.” (p.99) Most of the interactions happened opportunistically rather than on a schedule. They were fleeting conversations that occurred mostly in dyads and triads instead of the team. However they had very important implication for the formation, training and management of teams in health care settings. In addition, backstage communication contributed to more effective and efficient communications to patients, and might lead to better patient outcomes.

Another interesting study on backstage communication in hospitals was conducted by Iedema and his colleagues (2010). Based on an analysis of video-ethnographic data of a corridor in an Australian metropolitan teaching hospital, they found that corridors in hospitals were important “liminal” backstage spaces that facilitated the clinical work flow and multi-disciplinary collaboration. They claimed that corridor communication was important in medical education, especially in response to urgent issues. Corridor communication was also important places for clinical colleague

communication and consultation. For instance, 22 per cent of respondents have admitted to request a prescription from a work colleague during a corridor encounter (Shadbolt, 2002). Iedema et al. (2010) discovered that the neutral zoning of corridor helped negotiate or break down the traditional strictly defined professional boundaries, specifications, and rules. More interestingly, the authors pointed out that the “bulge” area; a widening of the walls in part of the corridor drew clinicians in and allowed them to have some sense of “being protected.” (Figure 3.1) The professional hierarchies are flattened out by the space that stepped away from traditional norms and conducts, thus made the interdisciplinary and multidisciplinary communication possible. If we try to understand the interdisciplinary and multidisciplinary communication happening in the corridor bulge, it is related to the degree of high level of visual control and low level of visual exposure provided by the bulge.



**Figure 3.1: The “bulge” area in the corridor of the Sydney Hospital, source: Long, Iedema et al. (2007)**

In short, backstage communication is an important component of face-to-face communication that helps flatten the professional hierarchies and helps to the formation

of interdisciplinary care teams. The provision of backstage space is able to provide the *privacy* for clinicians, which gives them an opportunity for self-disclosure and intimacy; respite from social role demands and an opportunity to rest; and an opportunity to practice new roles and self-images (Altman, 1975; Shumaker, 1979; Wolfe & Laufer, 1974). It is also important for effective learning as it provides a sense of safety. In that “psychological safe” environment, the learners will feel safe to experiment, voice their concerns, identify their lack of knowledge, and stretch their limits (Edmondson, 1999). In the backstage space, they can feel that there is no danger that they will unnecessarily distress or harm patients or their families and they are safe from humiliation.

### **3.3.2 “Community of Practice” and “Community of Interest”**

Another approach to facilitate face-face interactions in a multi-disciplinary care team is through controlling interfaces among different communities of clinicians. Rashid (2009) pointed out that there were two most pervasive types of communities among clinicians, communities of practice (CoPs) and communities of interest (CoIs). CoPs consist of practitioners who share a common knowledge or practice domain and who perform similar work tasks (Lave & Wenger, 1991). A group of nurses in a medical unit who meet regularly to share the experience of daily patient care is a typical example of CoP. CoIs are composed of members “from different knowledge and/or practice domains to perform a specific task.” (Rashid, 2009, p. 69) A typical example of CoI is a multidisciplinary team that formed around a specific case of a patient. Usually the team is composed of doctors, nurses, technicians, social workers, unit clerks, and other clinicians. Each member of the CoI can provide a unique set of skills and professional knowledge that other members usually do not have. Both CoPs and CoIs are important for patient care, even though their levels of importance vary depending on different patient conditions (level of acuity and complexity) and different purpose to reproduce knowledge or create new knowledge. CoP s are more important when the purpose is to preserve and



reproduce knowledge, while CoIs are more important when the purpose is to create and advance knowledge. The creation and evolution of CoPs and CoIs can be controlled by the program of the hospital unit and the interfaces among different categories of clinicians. For instance, a space with low connectivity and integration values restricts movement and interaction, thus preserves existing rules and procedures. It is ideal for the situation where the efficiency of carrying out standard care tasks is the major concern. On the contrary, a space with high connectivity and high integration values has high flexibility of movement and maximizes opportunities for encounter and interaction, thus can contribute to the creation of CoIs and advancement of knowledge. It is also beneficial for the new members of CoPs to have more opportunities to interact with old members, and move from the peripheral of the group to the center.

### **3.4 Summary**

This chapter has stressed the importance of face-to-face informal communication in healthcare settings, in terms of relieving stress, increasing job satisfaction, improving patient outcomes, and contributing to team collaboration. More importantly, this chapter has reviewed studies that demonstrate the close link between the design of hospital space and communication among multi-disciplinary care team. The results show that face-to-face communication can be affected by controlling the interfaces among different groups of users. For instance, the provision of backstage space to clinicians can help reduce the differences in rank, sex, and profession, and thus encourage the multi-disciplinary communication and collaboration. In addition, space with high integration and connectivity can enhance random encounters and interactions, which can contribute to the communication and coordination within the Community of Practice (CoP) and the creation of Community of Interest (CoI).

## **CHAPTER 4**

### **CULTURAL PROPERTIES OF COMMUNICATION IN CHINESE NURSING UNITS**

Most of the literature on face-to-face communication that was reviewed in the previous chapter was written in the context of Western culture. However, little research has done in the context of Chinese nursing units. As a carrier of culture, communication patterns are strongly impacted and regulated by culture (Chen & Starosta, 1998). As Wenger et al. (2002) have stated, “people’s willingness to ask questions that reveal their ‘ignorance,’ disagree with others in public, contradict known experts, discuss their problems, follow others in the thread of conversation- all these behaviors vary greatly across cultures.” (p.118) Therefore, it is imperative to examine cultural properties of communication in Chinese nursing units. This chapter starts from the examination of the national schema of organizational communication in China. Then we discuss communication patterns in the specific context of the inpatient unit. The factors that may influence communication patterns, such as the healthcare system, care team composition and education level, nursing staffing, and care model, are introduced.

#### **4.1 National Culture and China’s Organizational Communication**

Several scholars have examined the impact of culture on communicational behavior (Hall, 1966; Hofstede, 1984; Miike, 2002; Samovar, Porter, & McDaniel, 2009; Triandis, 1989). Among them, Geert Hofstede’s dimensions of national cultures are among the most influential works to date in the study of cross cultural communication and management. He defined culture as “the collective programming of the mind that distinguishes the members of one group or category of people from others.” (Hofstede, Hofstede, & Minkov, 2010b, p. 6)

Based on the extensive empirical investigations on a pre-existing bank of employee attitude surveys within IBM subsidiaries in 66 countries, Hofstede (1984) found four dimensions of cultures: *power distance*, *collectivism versus individualism*, *femininity versus masculinity*, and *uncertainty avoidance*. *Individualism or Collectivism* is defined by the degree ‘to which individuals are integrated into groups’ (Hofstede & Peterson, 2000, p. 401). *Power Distance* refers to ‘the extent to which the less powerful members of organizations and institutions (like the family) accept and expect that power is distributed unequally’ (Hofstede & Peterson, 2000, p. 401). *Masculinity versus Femininity* refers to ‘assertiveness and competitiveness versus modesty and caring’ (Hofstede & Peterson, 2000, p. 401). *Uncertainty Avoidance* indicates ‘to what extent a culture programs its members to feel either uncomfortable or comfortable in unstructured situations’ (Hofstede & Peterson, 2000, p. 401) .

Among the four dimensions, two dimensions seem to be particularly important for the cross-cultural communication studies (Triandis et al., 1986; Yang & Bond, 1990) . They can be viewed as vertical and horizontal differentiation of culture. The vertical differentiation refers to *power distance*, which is based on the distribution of power. The horizontal differentiation refers to *individualism/collectivism*, which is based on the distribution of responsibility.

Later, based on Michael H. Bond and other Chinese scholars’ Chinese Value Survey (CVS), Hofstede and Bond (1988) created the fifth dimension, the *Confucian dynamism*. They claimed that Confucian Dynamism can be categorized as *long-term orientation* versus *short-term orientation*. Long-term orientation refers to ‘persistence (perseverance)’, ‘ordering relationships by status and the observing of this order’, ‘thrift’, and ‘having a sense of shame.’ Short-term orientation is associated with ‘personal steadiness and stability’, ‘protecting your face’, ‘respect for tradition’, ‘reciprocation of greetings, favors and gifts.’ As the fifth dimension is based on Eastern values, and does

not match any existing Hofstede dimensions, it is considered as an additional measure that distinguishes the cultural orientation between Western and Eastern culture. Due to the limitation of the understanding of the Confucianism philosophy, the usefulness of Hofstede's fifth dimension of Confucianism Dynamism has received critiques from some Asian scholars (Fang, 2003; Yeh & Lawrence, 1995).

In this study, we adopt these three dimensions, *power distance*, *individualism/collectivism*, and *Confucianism* to examine the impact of national culture on communication patterns and its related spatial implications. For the Confucianism, we are not limited by the Hofstede's fifth dimension of *Confucian Dynamism*. Instead we have reviewed the works by many Asian anthropologists and sociologists to provide a more holistic view of the impacts of Confucianism on Chinese organizational communication.

#### **4.1.1 Collectivism versus Individualism**

The main difference between collectivism and individualism is the degree to which individuals are integrated into groups (Hofstede, 1984). The societies with individualism orientation usually have very loose ties between individuals. The responsibility is distributed among individuals, where "everyone is expected to look after him-or herself and his or her immediate family." The societies with collectivism orientation have strong, cohesive in-groups concepts, where people are expected to be closely integrated into groups and show their "unquestioning loyalty." (Hofstede, et al., 2010b, p. 92) China is featured as collectivistic culture whereas United States as individualistic culture (Hofstede, 1984). In collectivistic cultures, such as China, the group (e.g. work unit) is more important than self (Gao, Kao, & Ting-Toomey, 1998; Triandis, Bontempo, Villareal, Asai, & Lucca, 1988). The Chinese self would be incomplete if it was separated from others (Gao, et al., 1998). Here the group is not a universal group, but more of a group bound by social networks (Yum, 1988). It is also

very important for Chinese to establish and maintain proper social relationships within the group. Through the long-term relationships, the group members develop a strong sense of mutual dependency of each other and loyalty to the group. In addition, there is a sharp distinction between in-group and out-group members (Yum, 1988). An in-group is a group “whose values, norms, and rules are deemed as salient to the effective functioning of the group in the society and these norms serve as the guiding criteria for everyday behaviors.” (Ting-Toomey, 1994, p. 361) The in-group members may develop linguistic codes and rules that are unknown by out-group members. Frequent face-to-face interactions and especially small talks are imperative in maintaining the close ties among the in-group members.

#### 4.1.1.1 Frame/attribute orientation

The concept of frame/attribute orientation is closely related to the national dimension of collectivism and individualism. The difference between “frame-oriented” and “attribute-oriented” is that the former is more attached to certain team or unit; the latter is more attached to certain role (Nakane, 1970). On Nakane’s study on Japanese society, she pointed out that Japanese culture is frame-oriented in that Japanese people tended to identify themselves with a family or business grouping. On the contrary, American culture is attribute-oriented in that American people tend to identify themselves with different roles and professional label, such as “accountants” or “engineers.”(Zimring & Peatross, 1997) Similar to Japanese, Chinese people also tend to be frame-oriented with a strong affiliation with a social unit. People with frame orientations focus on the needs of the groups that they belong to. They might take different roles to ensure the overall performance of the group. The roles can be constantly renegotiated, which can be enabled by frequent face-to-face interactions within the group. People with attribute orientations don’t rely as much on the group identity. They depend less on other team members to perform their tasks.

#### **4.1.2 Power Distance (High versus Low)**

As aforementioned, collectivism/individualism is about the distribution of responsibility, whereas power distance is about the distribution of power. It is calculated from the answer by IBM employees in the same kind of positions on the same survey questions. A factor analysis was used to sort the survey into clusters. One of the clusters is related to power and equality. Three key questions are most important for power distance: 1) whether they are afraid to confront their managers? 2) what is the perception of the boss's actual decision making style? 3) what is the preference for their boss's decision making style? The Power Distance Index (PDI) is calculated based on the mean score of these three questions (Hofstede, Hofstede, & Minkov, 2010a). Based on the PDI score China is considered as a high power distance country (PDI score: 80), while the United States has relatively low power distance (PDI score: 40) (Figure 4.1) (Hofstede, et al., 2010a). In countries with large power distance, the organizations are represented as clear tall hierarchical systems with the power centralized in a few people's hands.

The difference in power distance has a strong influence in communication patterns. For instance, in the countries with high power distance, patients usually treat doctors as superiors and have less time and opportunity for communication and information exchange (Hofstede, et al., 2010a). In the work environment of high-power distance countries, subordinated are unlikely to challenge and contradict their bosses directly. The roots of Chinese people's high power distance can be traced back to the Confucianism philosophy that is deeply embedded in the Chinese culture with a history of more than 2000 years.

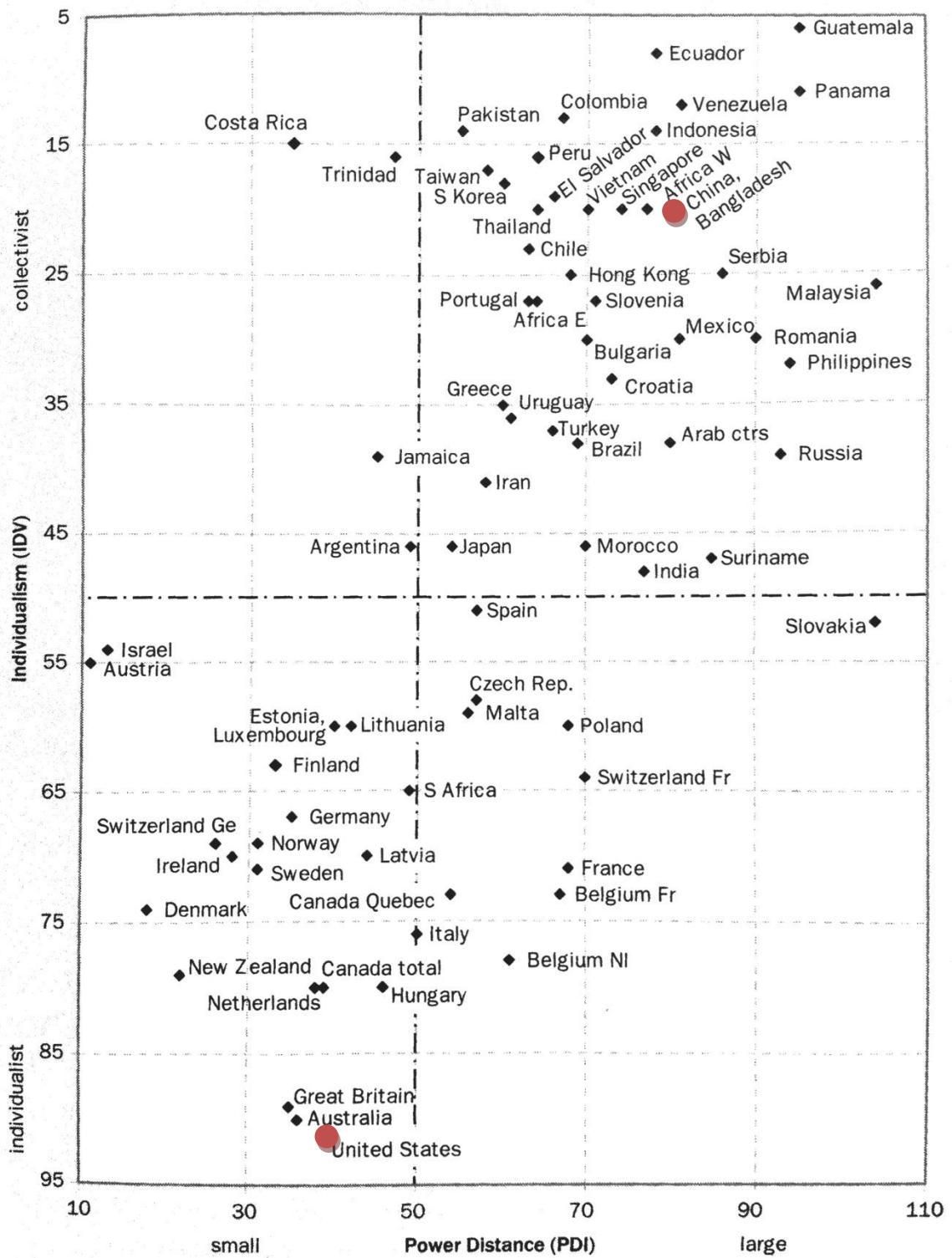


Figure 4.1: The matrix of power distance and individualism (Hofstede, et al., 2010b, p. 103)

### 4.1.3 Confucianism

Since the sixth century B.C., Confucianism has been propagated and educated as the societal rules and the source of values in China. As one of the most influential philosophies in China, Confucianism has profound influences on every aspect of life of the Chinese people.

#### 4.1.3.2 Hierarchy Social Structure (*Dengji*)

The essence of Confucianism is about order and interpersonal relations. Human relationships should be regulated by the Five Code of Ethics (*Wulun*), which is based on the five basic hierarchical relationships: 1) between parent and child; 2) between king and minister; 3) between husband and wife; 4) between elder brother and younger brother; and 5) between friend and friend. The hierarchical order in relations reflects not only in families but also in organizations. In workplaces, there is a well-defined hierarchical structure between supervisors and subordinates. A social unit is usually represented as a well-controlled tall hierarchical pyramid, which is congruent with the high power distance of Chinese organizations.

#### 4.1.3.3 Social Network (*Guanxi*)

The Confucianism also considers building and maintaining proper human relationships as the basis of society. “The Chinese rely heavily on interpersonal relations, called *guanxi*, built and maintained through mutual obligations that begin with family and friends and extend to organizational acquaintances.” (Samovar, et al., 2009, p. 300) *Guanxi* can be considered as a general form of social networking in the Chinese society (Yeung & Tung, 1996). The Chinese *guanxi* networks are built on the sustaining interpersonal interaction and reciprocal bonds (Fei, 1948). One important character of *guanxi* is that networks can be viewed as concentric circles. It is based on the differentiable order from the familiarization to alienation of *guanxi* degrees, moving from



close families to acquaintances, and then strangers, in accordance to the distances of relationships and degrees of trusts (Luo, 1997). The differentiable order of *guanxi* is closely related to the distinction between in-group and out-group that we mentioned earlier. Depending on the distance of *guanxi*, people use different communication styles to control the type and content of information exchange. It might be difficult for the “outsiders” or newcomers to get involved in the group unless they develop the understanding of the shared language, codes, rules and rituals of the group.

#### 4.1.3.4 Face (*Mianzi*)

The Confucian consideration of maintaining proper human relationships (*guanxi*) has led to the development of communication patterns that preserve one another’s face (*mianzi*) (Yum, 1988). According to Ting-Toomey (1988), “face” is a “strategy that protects self-respect and individual identity. Face saving activities are the rites that protect the individual’s role in the *guanxi* network, preserving individual identity and social status.” (p. 215)

To lose face in public is considered as a damage of one’s own image and will lead to an emotional uneasiness. A recent study conducted by Shan (Mavrides, 2009) from the China Youth Daily found that over 93% of the 1,150 respondents surveyed admitted that face was very important to them, with 75% acknowledging that making a mistake in public was, by far, the most humiliating experience they could ever have. The presence of others is an important factor that contributes to the feeling of “losing face.” (Yang, 1945) As Ho (1976) has pointed out, face is “the respectability and/or deference which a person can claim for himself from others.” (p.883) In other words, the feeling of losing face is dependent on the context and the setting. If people are confronted with any wrongdoing in public, they are more likely to feel embarrassed. As a result, a superior's disciplinary action to a subordinate in the Chinese organization is usually practiced by following the

saying “extol the merit in public hall; rectify the wrongdoing in the private room.” (Chen & Chung, 1994)

In addition to maintain one’s own face, it is also important for the person to have a sense of considerateness and try to maintain the face of the other participants during an encounter (Goffman, 2003). In order to save “faces” and preserve interpersonal harmony, people from collectivist cultures (such as China) prefer high-context instead of low-context communication style (Hall, 1976, 1983). According to Hall (1976),

*HC [High Context] transactions features pre-programmed information that is in the receiver and in the setting with only minimal information in the transmitted message. LC [Low Context] transactions are the reverse. Most of the information must be in the transmitted message in order to make up what is missing in the context (p.101).*

In high-context cultures, people rely on a broad range of social cues such as gestures and facial expressions to communicate. Face-to-face interactions become the most important way to communicate, in order to capture the between-line messages. In addition, it is important for people to be “spatially involved with each other,” so that they can be embedded in the context and keep informed. For high-context cultures, it is imperative for the team to “stay in touch” and “keep up-to-date,” to ensure the collaboration and coordination of the team (Hall & Hall, 1990, p. p.23).

In sum, Chinese culture is characterized as a collectivistic culture with frame orientation and high power distance. People in Chinese organizations tend to perceived themselves as part of a close-knit group instead of independent individuals. The Chinese organization is represented as a tall hierarchical structure. With the influence of Confucianism, the organizational communication can be characterized by the in-group versus out-group distinction; the respect of hierarchical order; the avoidance of conflict

the respect for “face,” and the high-context communication style (Gao, et al., 1998; Triandis, et al., 1988; Yum, 1988). As a result, face-to-face communication is the most preferable communication style in China. It works as an important medium to maintain existing relationships between group members. It can engender social bonding through engagement of human body in interaction and informal communication.

## **4.2 Spatial implications of Chinese Culture**

How does national culture relate to design? In this section, we map each dimension of Chinese national culture to its spatial implications.

### **4.2.1 The Spatial Implications of Collectivism and Social Network (*Guanxi*)**

The difference between collectivism and individualism mainly resides in the distribution of responsibility and authority. In collectivism culture, the responsibility is widely distributed among the group. The spatial implication is that the group’s identity is more important than individual identity, thus identifiable boundaries between the inside and outside group. Hillier and Hanson (1984) describe this type of space that has physically identifiable boundaries as spatial, whereas the abstract space without an identifiable boundary as transpatial. In addition, there are greater needs for the group collocation, physical proximity, and better visual connections that can bring group members together and create internal solidarity. A space with higher integration is helpful to create more opportunities of casual small face-to-face interactions, and maintain the bond among the group members.

The Confucianism concept of *Guanxi* has very similar spatial implications with collectivistic orientation, as its focus is to maintain the social network within the group and control the distinction and social distance between the in-group and out-group.

Therefore, the space is characterized by strong boundary between different groups and rich visual and physical connections within the group.

#### 4.2.2 The Spatial Implications of High-power Distance and Hierarchy Social Structure (*Dengji*)

The high-power distance is highly correlated with the concept of *dengji* in Confucianism philosophy. In the high-power distance culture, the concept of hierarchical order is well-accepted by the majority of the organization. The decision is usually made by few top managers in the organization (Hofstede, et al., 2010a). The distribution of power, in other words, the hierarchy is mainly conveyed through locations within the spatial configuration and symbols such as furnishings and materializations. For instance, the hierarchy is reflected on the way people seat themselves around the table at the official dinner (Pan, 2000) (Figure 4.2). The most important person or the one with the highest rank usually sits at the end of a big round table, facing the entrance. The guest of honor usually sits to the left hand side of the host. With the decrease of the rank/hierarchy, the rest of the attendants sit further away from the host and closer to the entrance.

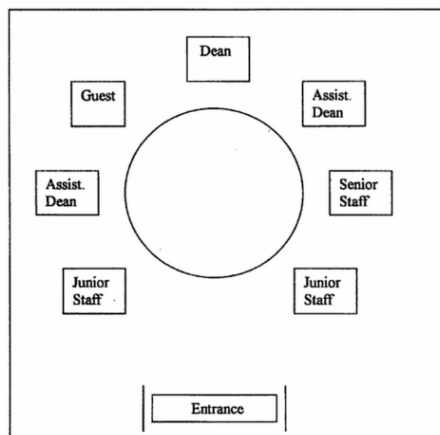


Figure 4.2: Seating arrangement of an official dinner (Pan, 2000, p. 84)

The hierarchical order is also reflected in all types of Chinese traditional architecture, including the courtyard house, official buildings, schools, temples, and palaces (Figure 4.3). The basic layout principles are symmetry, axuality, orientation, and the hierarchical order of spaces (Fu et al., 2002; Xu, 1998) . An archetypal courtyard house is normally constructed around a courtyard. The main halls are arranged along a north-south or longitudinal axis, while the side rooms are located on the flanks, symmetrical to the axis. Traditionally, the depth (length) of the axis was a symbol of social position (Xu, 1998). The privacy is also increased with the depth along the longitudinal axis. The space shifts from more public to semi-public and private with the increase of distance from the main gate. The most senior people in the family usually locate in the main hall at the north end of the longitudinal axis, which was the deepest in the space and protected by several front yards. Its inaccessibility and high sense of control is a symbol of the central authority and high status (Xu, 1998) (Figure 4.4).

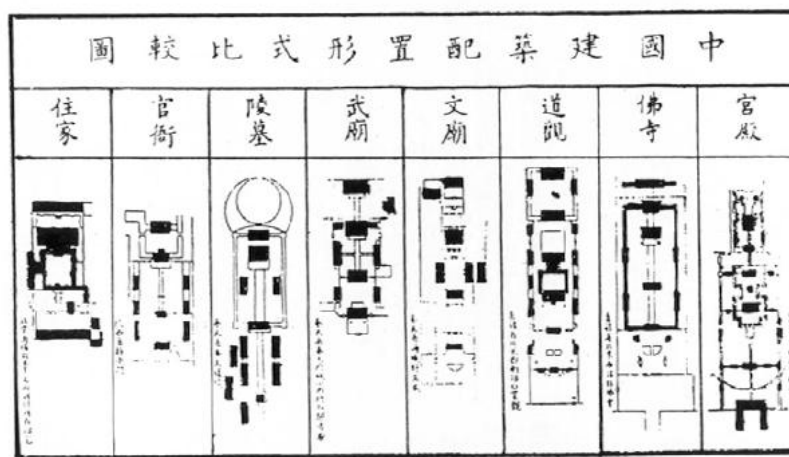
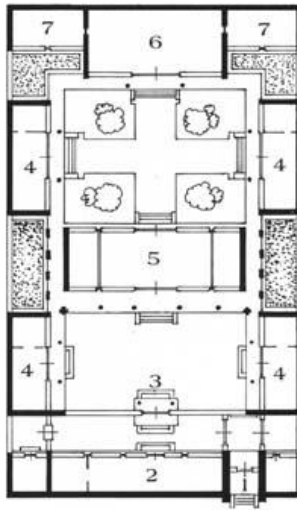


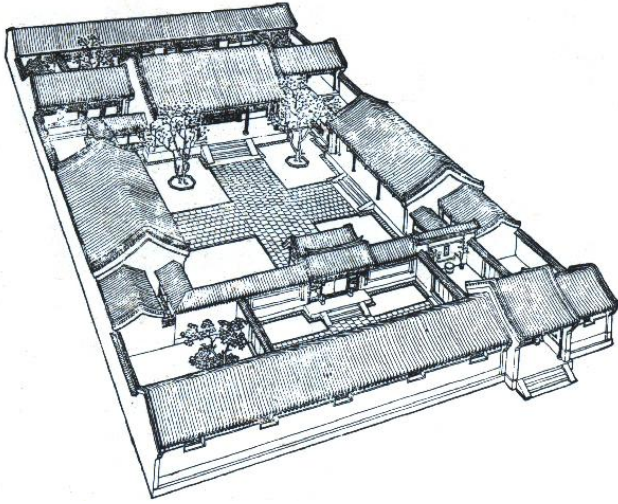
Figure 4.3: A layout comparison of different types of traditional Chinese architecture. Source: (Ito, 1937).



1. Main Entrance
2. Servants rooms
3. First courtyard
4. East and west-side rooms for the sons and daughters and their family
5. Inner hall for family gathering and guest greeting
6. Main hall for most senior members of the family
7. Side rooms for extended family members

**Figure 4.4: An archetypal Chinese courtyard house layout with symmetry, north-south axis, and hierarchical order (Yan, 1987, p. 247)**

Another key feature of the traditional Chinese courtyard house is the differentiated treatment between inside versus outside (Figure 4.5). The courtyard dwelling usually provides the family great isolation from outside, but little privacy inside in order to maintain social control within the family (Xu, 1998). The exterior walls of the courtyard house usually are very high with limited perforations. On the other hand, the inside of the courtyard house has little privacy. There is a rich visual connectivity among different indoor spaces that allow people to watch each other and maintain the order and proper behaviors. Wang and Ye (2005) pointed out that the centrality of courtyard house has constituted the “genotype” of Chinese domestic architecture, despite the modification and re-contextualization of the house forms to accommodate different local conditions.



**Figure 4.5: A courtyard house with the differentiated treatment between inside and outside (Fu, et al., 2002)**

### **4.2.3 The Spatial Implications of Face (*Mianzi*)**

The Confucianism's consideration of preserving one's face (*Mianzi*) can be translated spatially as the demand for the differentiation between backstage space and fronstage space. To ensure people can feel comfortable to contradict with supervisors or experts, or ask questions that might reveal their ignorance, or to admit mistakes and errors in China, it is important to have a clear boundary between different territories. The differentiation of public space, semi public/private space and private space is helpful for individual to control the social distance and avoid embarrassment in public.

Based on the above discussion, the national schema of Chinese can be translated into special needs of Chinese organizational communication, which in turn requires the certain spatial properties of physical environment to support those needs (Figure 4.6). The collectivism and the importance of maintaining social network lead to the sharp distinction between in-group and outside-group, and the needs for collocation to maintain the group solidarity. The resulting space should have a clear boundary between different territories. Meanwhile the in-group space should have good visual and physical connections. The high power distance and respect for hierarchy call for a space that can

demonstrate the tall structure of hierarchy. The focus on face requires privacy for backstage communication, which demands a space with clear boundary between frontstage and backstage and limited visual and/or physical access to public. The high-context communication style requires a space that allows group members to be easily accessible to each other.

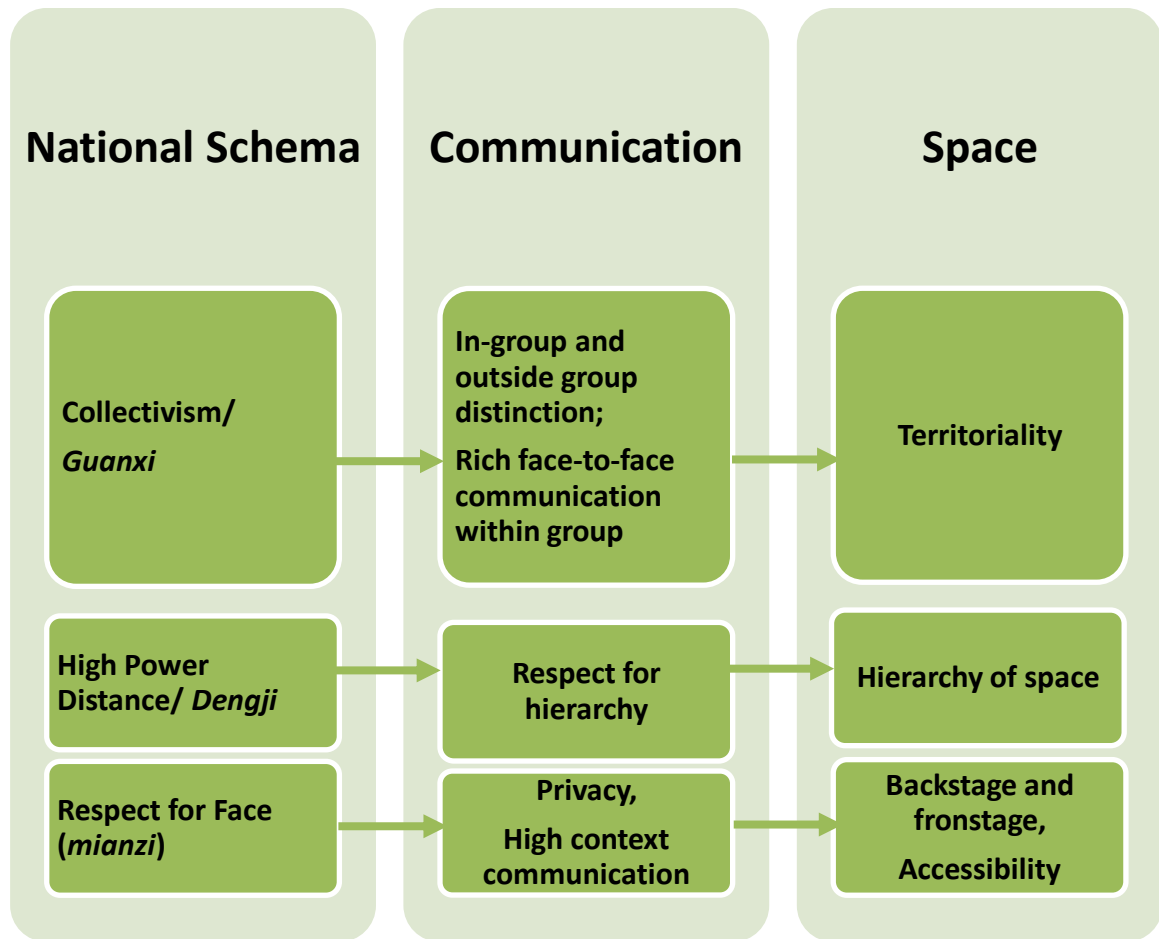


Figure 4.6: Link Chinese national schema to communication and space

### 4.3 Organizational Culture of Chinese Nursing Units

Organizational culture is a subset of general culture. According to Schein (2010, p. 19), “[organizational culture is] a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new

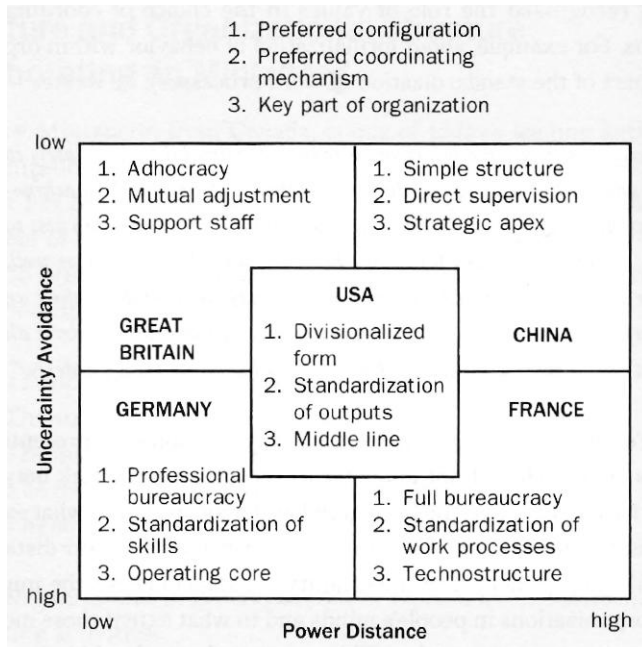


members as the correct way to perceive, think and feel in relation to those problems.” In other words, the core of an organization’s culture is the “shared perceptions of daily practices.” (Hofstede, et al., 2010b, p. 348)

Organization cultures distinguish different organizations or subunits of organizations within the same country. Actually any definable group with a shared history can invent, discover, or develop a culture.

#### **4.3.1 Factors that Affect Organizational Culture**

Organizational cultures are partly predetermined by given factors like nationality, industry, and task. Hofstede (Hofstede, 1985; Hofstede, et al., 2010b) has pointed out that among the dimensions of national cultures, the power distance and uncertainty avoidance were the most relevant dimensions that affect the structuring and functioning of organizations. According to the different combinations of power distance and uncertainty avoidance, he proposed four implicit models that people from different nations would prefer what an organization should be (Figure 4.7). For example, large power distance plus weak uncertainty avoidance leads to an implicit model of organization as a “family.” China is a typical example of this model. The preferred organizational configuration is “the simple structure.” The organization is coordinated through “direct supervision,” which focuses organization through personal intervention of the supervisors and the subordinates. While the U.S., as a nation with small power distance plus weak uncertainty avoidance, has an implicit model of organization as “village market.” The preferred organizational configuration is in a “divisionalized form,” which is coordinated through the standardization of outputs or desired results (Hofstede, et al., 2010b; Mintzberg, 1983).



**Figure 4.7: Five preferred configurations of organizations influenced by national culture based on Mintzberg's model (Hofstede, et al., 2010, p303)**

More importantly, organizational cultures are strongly affected by organizational characteristics including organizational structure and control systems.

#### 4.3.2 Organizational Structure of Chinese Inpatient Units

In this section, we examine the organizational structure and care model of Chinese nursing units with detail in order to understand their implications on the organizational culture.

##### 4.3.2.5 Health Care System and Organizational Structure

Most Chinese hospitals are public hospitals. By the end of 2010, there are only 7,068 private hospitals and 13,850 public hospitals, which account for 33.8% and 66.2% of total hospitals respectively (Center for Statistics Information, 2011). The working structure of public hospitals is strongly influenced by the concept of *danwei*, which means a socialist work unit. In their influential book *The Chinese Hospital: A Socialist*

*Work Unit*, Henderson and Cohen (1984) described the sociology of the *danwei* through their working experiences in a Chinese hospital attached to a provincial medical college. They declared that *danwei* was central to a Chinese worker's life. Most workers used to stay with the same job or *danwei* for their entire life. They have strong attachment to their work units. It is imperative for one's to maintain good relationship with their colleagues. One's career was highly determined by the internal structure and dynamics of the relationships (Madsen, 1984). Henderson and Cohen's (1984) described the relationships of administrators to staff and within the staff, i.e. among doctors, nurses, and technicians. According to their observations, doctors have a significant degree of autonomy due to their professional knowledge, while nurses and technicians occupy a subordinate position within the organization. Although today the concept of *danwei* has somewhat diluted due to the market-oriented economy, there is still a strong trace on the way organizations work and how staff relate to each other.

#### 4.3.2.6 Health Care Team Composition and Education Level

Beside its own health care system, China has developed its own classification of health workers and composition of care team. Health professionals include doctors, nurses, pharmacists, laboratory technicians, clinical radiologists, and other technical staff with advanced education.

Licensed doctors are medical graduates with at least a bachelor's degree and one year's internship. Licensed assistant doctors are medical graduates of 3-year tertiary medical education programs with an associate degree, or 2 years' medical education programs with a diploma, and one year's internship (Anand et al., 2008).

Nurses in China are trained as generalists rather than specialists. They are all Registered Nurse (RN) with no further differentiation, such as licensed nurse practitioner (LNP), nursing assistant, and unit secretaries (Kalisch & Liu, 2009; Xu, Xu, & Zhang, 2000). Ninety-nine percent of nurses are trained in secondary education programs (Xu, et al.,

2000). Their education has met a huge challenge from the increasing demands of patient-centered care and rapid changing technology. In addition to licensed nurses, there is another special group of caregivers in China working as nursing assistant (*peihu*). This group exists due to the great shortage of nurses in Chinese hospitals. Most of patients have companions either from family members or hired social workers to help with 95% of basic care tasks for patients, such as hygiene, feeding, transferring patients, toileting/tracking intake and output (Ji & Zhai, 2009; Kalisch & Liu, 2009). The majority of the social workers and family members have no background in medical education. Technicians are professionals who have undertaken specialized studies, and include pharmacists, laboratory technicians, radiology technicians, and other technical staff.

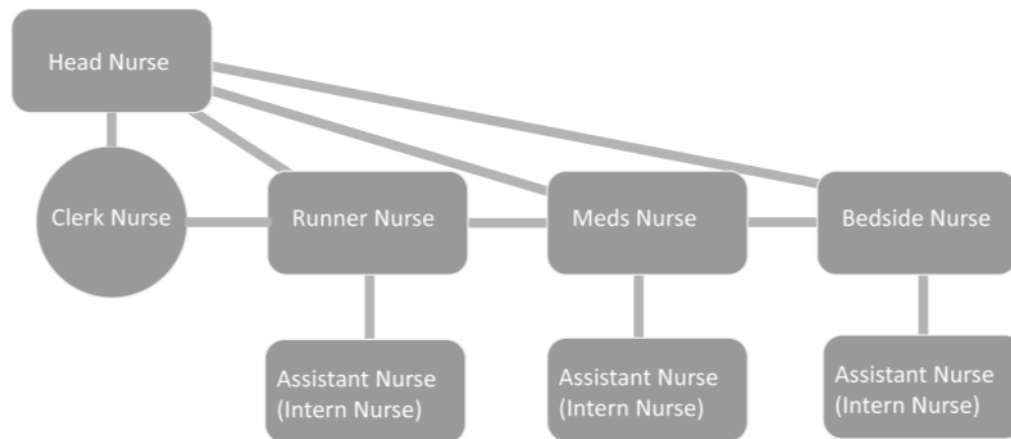
#### 4.3.2.7 Staffing Pattern

In China there are 1.05 nurses per every 1,000 populations, in contrast to the 9.37 in the United States (Kalisch & Liu, 2009). The typical staffing standard in China is called “staffing quota formula.” According to the standard, the bed-to-nurse ration is at least 1:0.4 in each unit. However this ratio is not the actual staffing ratio on each shift, instead, it is a ratio based on the total number of employed nurses in each unit (Kalisch & Liu, 2009). Hence the actual ratio of patients versus available nurses is even lower. According to a comparative study between a Chinese and an U.S surgical inpatient unit, the average nursing hours per patient day (HPPD) is way lower in China than in the United States, which is 2.78 versus 9.05 correspondingly (Kalisch & Liu, 2009). In addition, there is a great difference in the nurse-patient ratio between day shift and night shift. During day shift, the nurse-patient ratio is about 1:4, while during the night shift, the nurse-patient ratio is about 1:15-23 (Kalisch & Liu, 2009). Besides the pressure of the nurse shortage related to patient number, the composition of care team is also ill-balanced. In China the current doctor/nurse ratio is 1:0.42 in contrast to 1:2 in developed countries (Li, 2007).

#### 4.3.2.8 Care Model

In this section, we examine the care model in Chinese nursing units based on both existing literatures and my interviews with several hospital administrative staff and nurses during my visit to more than twenty Chinese hospitals in 2009. The care model is highly dependent on the care team composition and the role of nurses. The current care models in China have two types: functional task-based care, and patient-centered team-based care (Luo, 2007). For functional task-based care, the nursing team is arranged as an assembly line. Each nurse will be assigned roles that involve certain types of care tasks. For example, the “head nurse” (护士长) is in charge of the administration and management of the unit; “clerk nurses” (办公室护士) are in charge of charting, taking notes from doctors, and delivering the doctors’ requests to other nurses; “meds nurses” (药疗护士或治疗护士) only take care of the medication tasks, including medication preparation and administration; “runner nurses” (通勤护士) are responsible for stocking supplies, getting medication from central pharmacy, sending patients to and back from surgeries and exams; “bedside nurses” (临床护士) are those who provide most of the direct care to patients, including the basic care and monitoring patients’ condition; “nurse assistants” (助理护士) are usually intern nurses who are not allowed to conduct any direct patient care but assisting the surveillance of patient conditions and facilitating other nurses’ tasks when needed (Figure 4.8) (Anonymous, 2012). Nurses are not fixed to one specific role. They rotate in their roles with each shift. For instance, one nurse can be the bedside nurse on her Monday morning shift, but turns into a meds nurse on her Wednesday afternoon shift. Moreover, although nurses are assigned to different roles during the beginning of her shift, it is not uncommon for them to be called on to deliver services outside of their assigned roles.

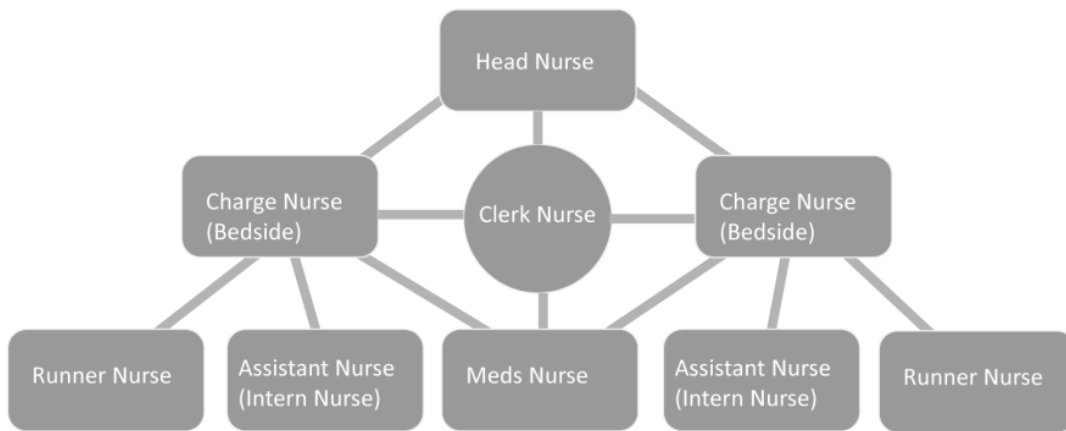
The task-based model is based on a flat hierarchical structure that relies on direct supervision from the head nurse. In addition, this model focuses on work efficiency and treats each nurse as a part of an assembly line. But there is a lack of consistent understanding of patients' condition and holistic care for patients. Frequent communications are needed in order to exchange information of patients, and coordination care tasks.



**Figure 4.8: The structure of the task-based model**

Some Chinese hospitals are moving towards the patient-centered team-based model (Figure 4.9). This model has been widely accepted in the United States. However the model has been modified to fit the situation of the shortage of nursing staff and high patient to nurse ratio in China. In the adapted model, nurses in one unit are usually divided into two or three groups. Each group is led by a charge nurse, who is in charge of 15-20 patients. Within each group, there is one runner nurse and some intern nurses to assist the charge nurse. One unit normally has one med nurse that helps all teams with issues related to medication. Clerk nurse is the center of information. She delivers information to the head nurse, charge nurse and med nurse. The head nurse is on the top of the pyramid structure. She monitors and directs the work of clerk nurse and charge nurses. This model is based on a somewhat more vertical relationship. It allows more localized communication. However, because the tasks are still distributed to different

nurses, constant communication and coordination is needed to enable the smooth operation of the unit.



**Figure 4.9: The structure of the team-based model**

#### **4.4 Implications of Organizational Culture on Chinese Nursing Unit Design**

Both the national schema and the concept of *danwei* have strong impacts on the organizational culture of Chinese nursing units. The preferred organizational configuration is a simple structure that is coordinated through direct supervision. It is based on a model of “family” structure, which relies on close relationship among group members. The great shortage of nurses has led to the staffing and care models that focus on efficiency. In order to maintain the organization as a close-knit “family,” and facilitate information exchange and task coordination, a dedicated staff zone with rich visual and/or physical connections is needed.

#### **4.5 Summary**

This chapter focused on examining the cultural aspects of face-to-face communication based on the analysis of national culture and the specific organizational culture in Chinese hospitals. The first step was an investigation of the national schema of organizational communication in China, accomplished through a review of the cultural dimensions discovered by Hofstede and others. Confucianism was also carefully studied

to show how its key concepts are linked to organizational communication. Based on the review, three main characteristics of Chinese national schema were identified: collectivism and the importance of maintaining social networks; the large power differential, coupled with a tradition of respect for hierarchy; and the respect of “face.” This then led to a discussion of the spatial implications of the national schema. Three spatial properties were argued to be important for supporting the Chinese national schema and related organizational communication: territoriality, hierarchy of space, and backstage space. Territoriality, establishing a clear distinction between the in-group and the outside-group, helps define group identity and supports collectivism. Hierarchy of space both demonstrates and maintains the power relationship. Backstage space with limited exposure to the public enables the protection of “face.”

This analysis is followed by the examination of the organizational culture in Chinese inpatient units. In order to understand the organizational structure and related communication patterns, several factors were investigated, such as the healthcare system, care team composition and education level, nursing staffing, and the care model. Chinese nursing units were characterized as a “family” structure with efficiency driven care models. The organizational structure of Chinese nursing units requires a well-connected workplace that allows frequent movement and informal interactions.

The following chapter explains how the spatial properties that support the national schema and the organizational culture of Chinese nursing units can be translated into spatial metrics.



## **CHAPTER 5**

### **SPACE SYNTAX STUDIES ON THE IMPACT OF LAYOUT CONFIGURATION ON FACE-TO-FACE COMMUNICATION**

A number of studies in space syntax have examined the relationship between spatial layout and behavior such as movement, face-to-face communication, personal encounters, co-awareness, and the creation and maintenance of interfaces between various user groups. This chapter reviews the analytical techniques that space syntax scholars have used to describe spatial configurations and link physical environments with spatial behaviors. More importantly, through extensive reviews on existing studies on the impact of spatial configurations on communication, this chapter defines the metrics that are most relevant for representing the cultural properties of space that impact face-to-face communication.

#### **5.1 Space Syntax as the Social Logic of Space**

Space syntax scholars are especially interested in the inter-relationship between human behavior and space at different scales: buildings, settlements, and cities. The central premise of the space syntax is based on the recognition of architecture as an interaction between social logic of space and spatial logic of society. The spatial form is a dynamic result of the two joint forces. Buildings constitute the social organization of everyday life as the spatial configurations of space and physical configuration of forms. Space at the same time shapes and modifies culture, instead of simply representing culture. In other words, society and space modify and restructures each other (Bafna, 2003).

### 5.1.1 Genotype of Space

One of the major implications of space syntax theory is to consider building as an aggregation of elementary cells that are governed by certain rules. In order to understand the spatial form of a building, we firstly need to understand the elementary unit. For the elementary cells, there are two pairs of properties that are important to describing spatial relationships: symmetry/asymmetry and distributedness/nondistributedness (Hillier & Hanson, 1984) . In building interiors, the distinction between symmetry and asymmetry is the distinction between spaces that have direct access to other spaces without having to pass through one or more intermediary spaces and spaces whose relations are only indirect. The difference between distributedness and nondistributedness is the distinction between spatial relations with more than one, or only one locus of control with respect to some other space (Hillier & Hanson, 1984). The two pairs of properties of space can be quantified to investigate some fundamental aspects of the social relationships built into spatial form. For instance, relative asymmetry can articulate the categories embodied by the space; and distributedness can articulate the relations of control of boundary in the system. A building therefore can be defined as a certain order of categories and a certain system of controls. It forms an interface between inhabitants and visitors, and between different categories of inhabitants. The inhabitants are those whose social knowledge are embedded in the categories, and the visitors are those whose relations with them are controlled by the building (Hillier & Hanson, 1984). The order of categories and the system of control are specified by rules and mapped into space.

Spatial system is an interaction between rules and randomness. Without the rules, the layout would be just random aggregation. Steadman (1983) used the term ‘combinational explosion’ to refer to the great numbers of possibilities for rectangular arrangements with increasing numbers of rectangles  $n$ . In order to restrict possibility and lead to finite set of ‘actual’ patterns, there has to be ‘architectural requirements’ or rules.

There are at least two different dimensions of rules can be applied: spatial and transpatial. Spatial dimension refers to the spatial relationship, such as the proximity of elements (Hillier & Hanson, 1984). However, all the cells are interchangeable under the relations specified by the genotype. Transpatial dimension refers to the relations that are “not within the system but outside it in other comparable systems across space.” (Hillier & Hanson, 1984) It is based on the assignation of different labels to different groups of individuals. Labels are socially invested transpatial rules, which add non-interchangeability to spatial elements, by defining the specific relations between particular spaces to others spaces. Social meanings can be considered as transpatial rules. The length of the rule expresses differences in the amount of social meaning invested in the pattern. Transpatial dimension has its own consistency as it is realized in one local discrete system in the same form as it is realized in others. For example, kinship system will lead to well-defined spatial outcomes in terms of the proximity, permeability, and patterns of encounter. The constant relationship between the labeled spaces, and the type of relational differentiation of the functions and categories located in different spaces within a plan is defined as an ‘inequality genotype’ (Hillier & Hanson, 1984). In other words, labeling a space is an aspect of reproducing typical programs of function, behavior, and space use. Through examining the building genotype, we can understand the cultural input in buildings, even the historical processes of change (Hillier & Hanson, 1984; Steadman, 1983). For example, Bafna (2001) compared a large sample of Miesian country houses (24 houses) to 15 country houses from the same period as the Miesian houses. He selected a set of eight space labels that recurred in each house, which were sufficiently distinct yet able to capture the full spectrum of domestic activities. The cell plot of the rank of these spaces indicated that there was a strong pattern to the variation. The results confirmed a non-random variation pattern of the values. Hence he redefined the genotype as a statistically stable pattern of variation instead of a given rank order of

labeled spaces. The variable range allowed the innovations of design, but at the same time keep it sociologically fit/stable.

When the spatial rules and transpatial rules achieve a correspondence, encounters will reinforce the spatial relationship and becomes locally strong. It will lead to an exclusive and an internally hierarchical organization with strong rules, and strong boundaries. By contrast, when the spatial rules and transpatial rules are non-correspondent, the spatial group works locally and transpatial group works across space, causing movement and random encounter between individuals from different spatial groups. The system tends to be globally strong rather than locally. This will lead to an organization with non-exclusivity, weaker rules, weak boundaries and lack of hierarchy. In other words, correspondence system is more ‘reproductive’ of social knowledge; while non-correspondence system is more ‘productive’ of social knowledge. Therefore, spatial organization is a function of the form of social solidarity, and different forms of social solidarity are themselves built on the foundations of a society as both a spatial and a transpatial system (Hillier & Hanson, 1984).

### **5.1.2 Strong Programs and Weak Programs**

Depending on the length of the description for the rules, the genotypical models can be categorized as “long models” for long description of rules and “short models” for short description of rules (Hillier, 1996). The length of rules can define the strength of genotypical model to control the interface between users: the longer the description of rules, the stronger the genotypical models. Based on the strength of genotypical model to control the interface, buildings can be differentiated into strong program mode and weak program mode (Hillier, Hanson, & Peponis, 1984). Here program is not the list of roles and statuses of the organization. Program refers to the spatial dimensions of an organization. Strong program buildings are strongly determined by programmatic requirements. Everything that occurs in strong program building is specified by explicit

or implicit rules, and built into the spatial structure of the building. In weak program buildings, the law of space takes over the social program, and define pattern of movement and encounter. In the chapter of “visible college,” Hillier and Penn (1991) reinforced the difference between strong and weak programs, and their relationship to knowledge. For strong program buildings, the space structure and movement are controlled by social knowledge. For weak program buildings, the distribution of space use and movement are defined less by the program and more by the structure of the layout itself. Hence a weak program building is related to random encounter and morphogenesis. More importantly, it is generative or creative of knowledge. A major daily newspaper firm is used to exemplify a weak program building. Its layout is found to support the creative organization functions by sustaining co-presence and random encounter. The authors then conduct a comparative case study of two UK research labs (X & Y). They map the pattern of use and compare to the spatial analysis. It shows that the interactions in Lab X tend to reinforce the distinctions between groups, while the interactions in Lab Y tend to spread across groups. They infer that Lab X is more about the reproduction of knowledge while Lab Y is more probable to produce knowledge because of the probabilistic contact. Hence, the space is ‘generative’ of scientific knowledge when it can randomize social knowledge, and break through the existing organizational boundaries.

### **5.1.3 Understand hospitals from the space syntax’s point of view**

Hillier, Hanson and Peponis (1984) use some medical buildings to explain the interfaces and the differences between strong program and weak program. A small doctor’s surgery is a clear example of the strong program building, as the interfaces are well defined by the strong genotypical spatial requirements. When the scale of medical building becomes larger, some of the elements from the genotypical model may be taken over or missing. There will be either morphological discontinuity or social strategies to compensate it. However when buildings become more complex, the random encounter

and unprogrammed interactions are going to increase since they are more defined by the spatial layout and less by the program. The space in weak programmed buildings become the generator of social field, shape and organizes the social identity of space. In that sense, a nursing unit can be viewed as an intermediate level of configuration that combines both aspects of strong programming and weak programming. On the one hand, the nursing unit contains spaces that have strong pre-defined programs, such as the transpatial relationship between nurse station, patient rooms, medication rooms, clean and soiled utility rooms, and treatment rooms. Meanwhile, in the “back of the house,” the staff zone has a comparatively weaker program that allows the random encounter and interaction among care givers.

In summary, space syntax theory provides theoretical foundations for the comparison of The U.S. and Chinese nursing units, since the cultural and sociological significant aspects of a building are directly reflected in its spatial configuration. The “inequality genotype” can be represented through the ranking of programmatic labeled spaces according to their mean depth in the graph of the spatial configuration. In addition, we have to recognize nursing units as a combination of strong programmed and weak programmed spaces. The spatial configuration should resolve the seemingly conflicting demands: the disciplined routine of patient care procedure that is reflected in ordered transpatial relationships, and the active interaction and random encounter among caregivers that is defined by spatial relationships. The space thus acts as a mechanism to control the different interfaces among patients and staff, among orders and flexibility. The next section will discuss the techniques and measures that space syntax uses to analyze spatial configurations.

## **5.2 Analytical Techniques and Measures of Space Syntax**

Space syntax has set up the descriptive theory and other various techniques to analyze space through identification and representation of spatial elements, the

categorization and analysis of spatial relations, and the modeling of common or “genotypical” patterns. We will briefly review them and discuss the relevance of each method and spatial measure to our research questions.

### 5.2.1 Axial Maps

Based on the close link between visibility and movement, space syntax scholars have developed an analytical technique to represent the spatial structure of layouts as sets of intersecting lines, which are called “axial map” or “linear representation.” (Hillier & Hanson, 1984) Axial map is the set of fewest and longest lines of sight or access that passing through all spaces of a system. It is based on the assumption that the number of turns is more crucial to spatial experience than actual distance covered (Bafna, 2003). Hence the measures focus on the topological relationship instead of metric distance.

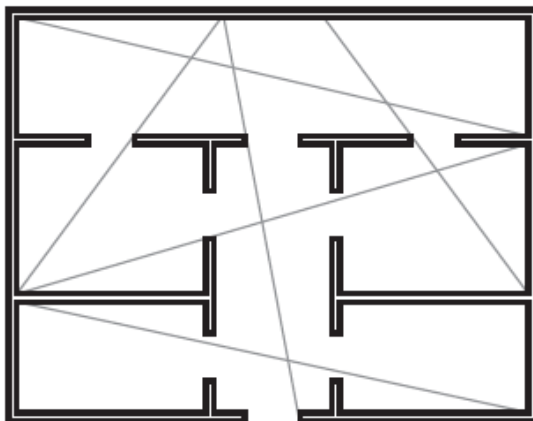
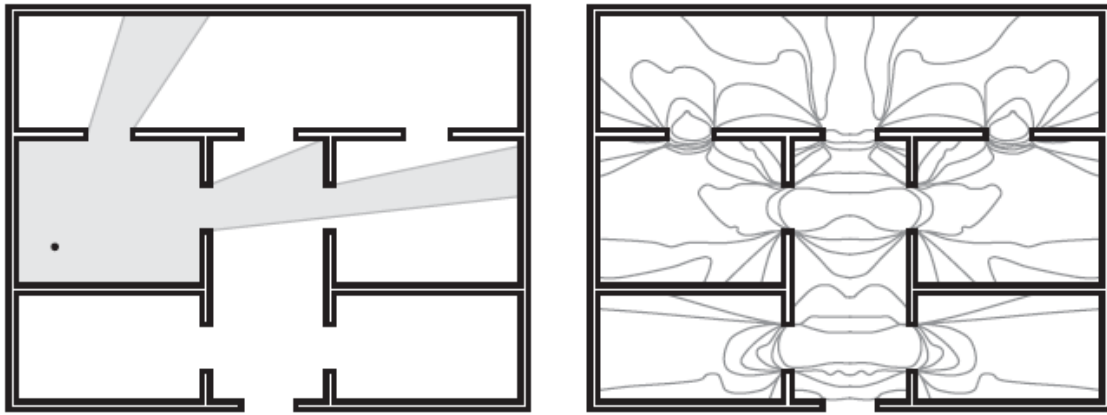


Figure 5.1: The axial map (Turner, 2004, p. 660).

### 5.2.2 Isovist

Isovist is “the set of all points visible from a given vantage point in space and with respect to an environment.” (Benedikt, 1979, p. 47) Measures of isovists, such as their areas, perimeters, occlusivity, circularity and radials variance and skewness, can be used to compare the quality of different spatial experiences (Figure 5.2). In order to understand the whole configuration, Benedikt (1979) suggests using “isovist fields” to

record the isovist property for all locations in a configuration. The change in a given measure of an isovist in all locations of a layout is plotted out through contour lines. Benedikt (1979) suggests that the rate of change of the isovist field is closely related to the perception of space and behavior such as movement.

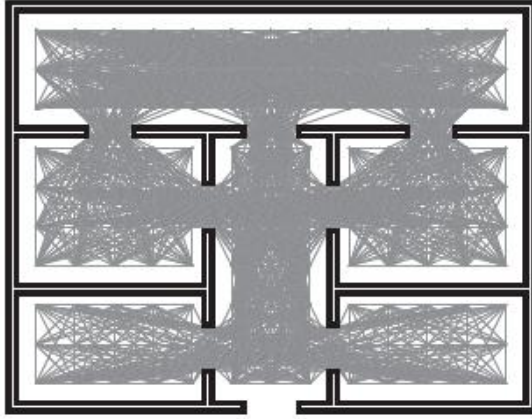


**Figure 5.2: The isovist and isovist field (Turner, 2004, p. 660).**

### **5.2.3 Visual Graph**

Based on the idea from Benedikt (1979) that “the experience of a space is related to the interplay of isovists,” Turner and his colleagues (Turner, Doxa, O Sullivan, & Penn, 2001) developed the technique of visual graph. This is used to determine how visible any point in the spatial configuration is from any other point (Figure 5.3). Based on the technique, they developed the software named “Depthmap.” The program divides any given plan into a grid, whose size can be determined by the user. All mutually visible points across the grid are connected. The resulted visibility graph has two sets of elements, the set of vertices and the set of edge connections joining pairs of vertices. The properties of isovist are represented in several different measures based on the number of vertices and edges (Turner, et al., 2001).





**Figure 5.3: The visual graph (Turner, 2004, p. 660).**

#### **5.2.4 Measures of Spatial Analysis and Related Concepts**

As has been mentioned above, space syntax uses different techniques to represent space as a relational spatial structure. The spatial relationship between the spatial elements such as boundaries, convex spaces, axial lines and units can then be described by several measures. By applying these measures to description of building form, space syntax scholars believe they can capture the spatial and functional differences in different plans.

##### ***Connectivity***

The *connectivity* is a local spatial property that is based on how many immediate neighbors each node can see. It can reflect the degree of direct visual connection (Turner, 2004).

##### ***Integration***

The integration value is closely related to the concept of mean depth. Mean depth (or mean shortest path length) from a line/vertex is the average number of edge steps to each any other line/vertex in the graph using the shortest number of steps possible (Turner, 2004). It equals to an average of the number of turns required for moving within the system plus one. Based on the concept of depth, a *Real Relative Asymmetry* (RRA) value can be calculated by a simple algebraic function that relates the depth of a node by

the overall number of nodes in the system. It has applied a correlation factor to eliminate the empirical effects of size and permits cross comparisons of systems of different sizes. The integration value is the inverse of RRA values ( $1/RRA$ ) (Bafna, 2003). Global integration is a global value based on the depth from one node to all other nodes in the system with radius  $n$ . While local integration value ( $1/RRA_3$ ) is based on the depth of one node to adjacent graph nodes up to three steps away (radius 3) (Turner, 2004). Global integration values have found to be highly correlated with pattern of global movement, encounter and interaction (Grajewski, 1993; Penn, Desyllas, & Vaughan, 1999; Peponis et al., 2007; Rashid, Kampschroer, Wineman, & Zimring, 2006; Rashid & Zimring, 2003; Sailer, Budgen, Lonsdale, Turner, & Penn, 2009; Sailer & Penn, 2007; Serrato & Wineman, 1999). Local integration values are closely related to pattern of local movement and control (Hillier & Penn, 1991; Penn & Hillier, 1992). The difference between global integration and local integration can help us understand to what extent does the spatial system differs from the global to local levels.

### **5.3 Studies on Layout Configuration and Face-to-face Communication**

Space, as a container of people's daily activity, strongly influences the way people meet and interact with each other (Hillier, 1996). Most of face-to-face communications are unplanned, impromptu conversations that are based on encounters. They happen in a social situation, which is "an environment of mutual monitoring possibilities, anywhere within which an individual will find himself accessible to the naked senses of all others who are 'present', and similarly find them accessible to him." (Goffman, 1964, p. 135) In other words, it is based on the proximity to others, and co-awareness of others' presence. Good design of physical environment can be viewed as an affordance or "opportunity" to overcome social and organizational barriers.

Physical proximity and accessibility are proven to be important for affecting the duration and rate of social interactions. For instance, studies have shown that the length

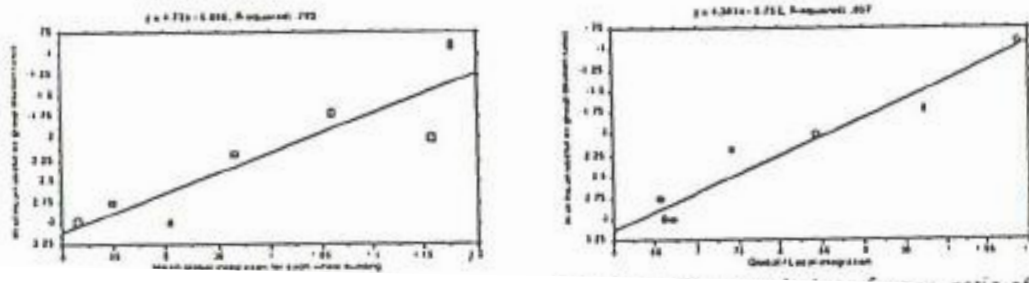
and strength of interactions among office workers are influenced by their physical proximity. Beyond a distance of about 30 meters, workers are not likely to talk (directly) unless there is a particularly important matter (Allen, 1977). In their study of two research and design laboratories, Serrato and Wineman (1999) also found that the rate of interaction is correlated to the distance from the scientist's office to the location of interaction. Similarly, Rashid & Zimring (2003) pointed out the lesser the travel distance between workspace, the higher the potential of interaction.

Scholars from Space Syntax have further linked some specific spatial properties to behavior, including movement, co-awareness, planned and unplanned interactions and the creation of interfaces between different organizational groups, roles and statuses (Grajewski, 1993; Penn, et al., 1999; Peponis, et al., 2007; Rashid, et al., 2006; Rashid & Zimring, 2003; Sailer, et al., 2009; Sailer & Penn, 2007; Serrato & Wineman, 1999). They suggest that the spatial configuration would impact the social behavior and interaction pattern in workplace environment. Layout attributes such as visibility and accessibility are important factors in deliberate users' movement, face-to-face communication, and organizational performance. Higher visibility and accessibility of space can predict larger possibility of informal interaction; hence contribute to innovation and knowledge transmission. (A summary of the extensive review of the space syntax studies on spatial configuration and organizational communication is provided in Appendix A).

For example, some have found mean spatial integration to be the main factor ( $r=0.59$ ) for determining levels of movement affecting observed levels of interaction and eagerness to travel for interaction in offices (Grajewski, 1993; Hillier & Grajewski, 1987). Similarly, Hillier and Penn (1991) find a strong and significant correlation between integration value of axial maps that represent the spatial configuration of a

London daily newspaper office and the density of moving people in space ( $r=0.83$ ,  $p<0.001$ ).

Through studies on a sample of 24 floors of seven laboratory buildings, Penn and Hillier (1992) demonstrated that the mean degree of spatial integration of axial maps of the floor can predict the strength of the networks strongly and significantly. They point out that the opportunity for movement and then the opportunity to be recruited into interactions are the key to maximize work related communication. The rates of "useful" work related inter-group communication is strongly related to building integration ( $r=.891$ ,  $p<.0005$ ). More spatially integrated buildings increase the level of useful work related inter-group communication. In addition, the ratio of global integration (1/RRA) to local 3 step integration (1/RRA3), in other words, the local to global integration interface is an even stronger predictor of "useful" inter-group communication ( $r=.968$ ,  $p<.0001$ ) (Figure 5.4). The results reiterate the earlier findings of Hillier and Penn (1991) and Hillier, O'Sullivan, Penn et al. (1990). It confirms that the more the patterns of local system resemble the patterns of global system, the more interactions happen outside the immediate group.



**Figure 5.4: The Correlation of the mean integration value for each whole building with the mean useful contact rates for all the buildings in the sample (left); the correlation of mean ratio of global to local integration with mean useful contact rates for each building in the sample (Penn & Hillier, 1992, p.43)**

Serrato and Wineman (1999) investigate the relationship between the layout of two research and development facilities and communication patterns among research

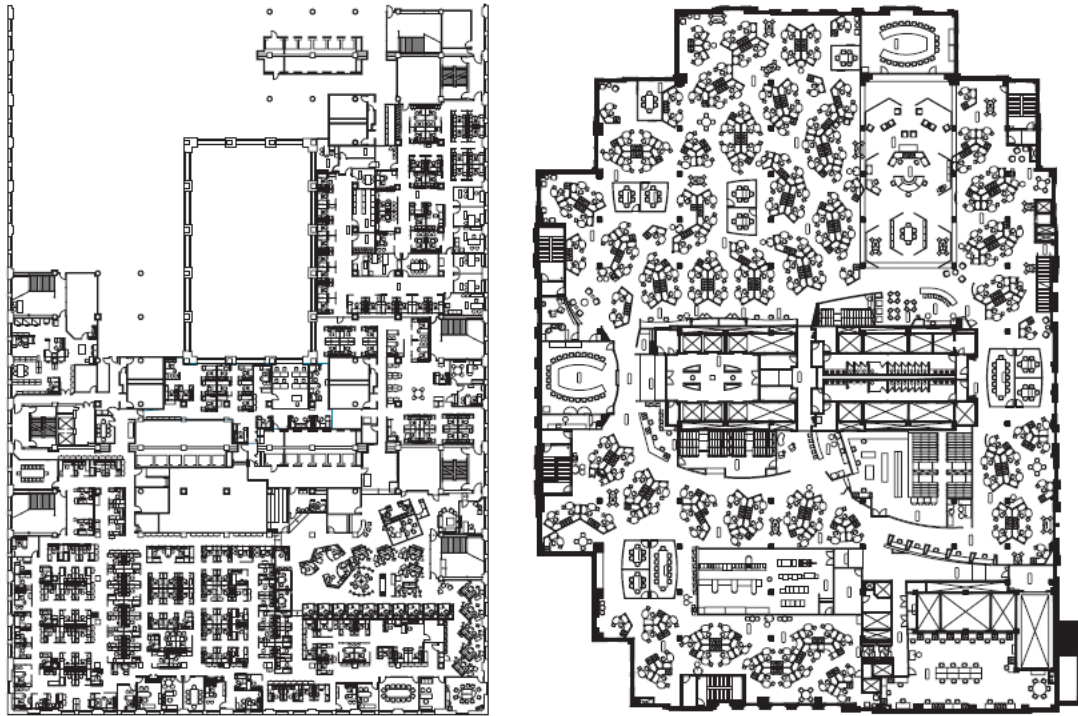
scientists. The difference between two labs is that: one lab tends to maintain the organizational subdivision by knowledge area; the other lab tends to mix knowledge areas and create interaction across the global system. The spatial measures are the global integration (RRA), local integration (RRA3), and the local-to-global interface (the ratio between the local and global integration). The behavioral data they have collected include the frequency, location and status of interaction, which is obtained through randomly paging participants and asking them to log their behavior in hand-held min-recorders. The results show that the local to global interface is a strong predictor of both the rate of linked interaction along the corridor and individual scientist's rates of interaction. That means, the better the hallway is an integral part of the local circulation system, and the better the local circulation interfaces with the global system of movement in the office, the higher the rate of interactions. In both facilities, spatial layouts enhance local networks; however, in one of the labs these local networks is separate from the global spatial system, while in the other lab the interface between these systems is strong.

Later in a study on two advertisement agency companies, Penn, Desyllas & Vaughan (1999) find that the patterns of space use and space configuration directly impact the frequency of contact and communication between workers. The spatial structure of the buildings could integrate or segregate people from other people, controlling their availability by spatial differentiation. They point out that the location of a workstation would directly affect the person's possibility to contact with others. People who are located in the more accessible spaces in the building are both more visible and directly reachable by others, thus have more opportunistic encounter and interaction and might be aware of a far greater number of people ( $r=0.898$ ,  $p=0.0001$ ). They also confirm that seeing each other more frequently might raise the awareness of other people's contribution to someone's own work. The usefulness of someone to those who do not

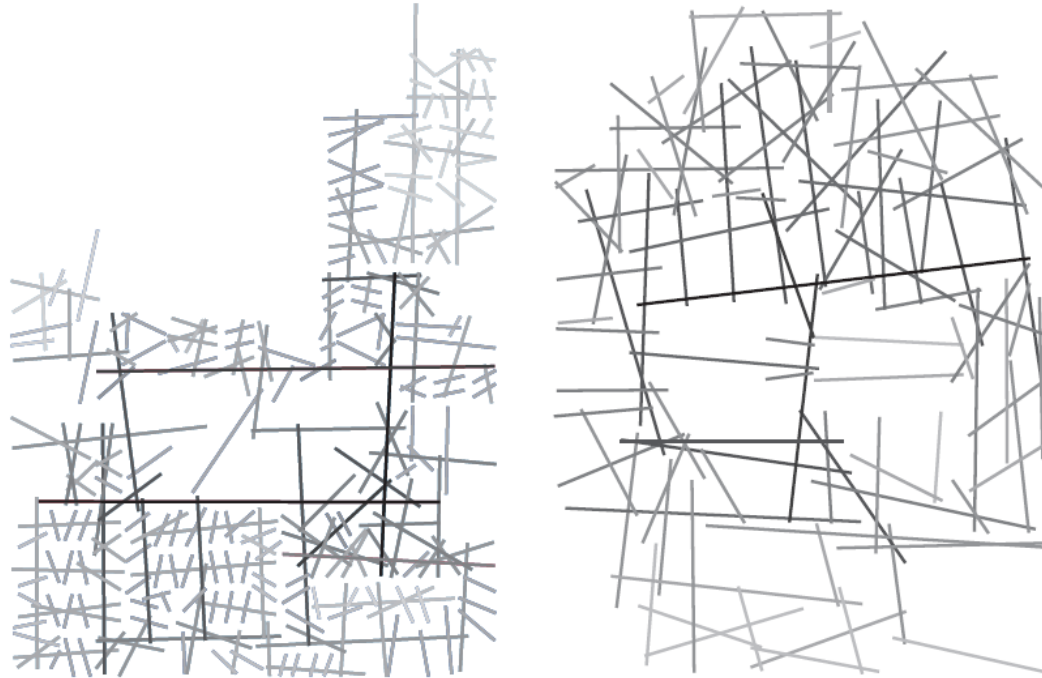
work with him is related to the average spatial integration of his work area ( $r=0.928$ ,  $p=0.721$ ).

Rashid and Zimring (2003) link five organizational constructs: *communication*, *control*, *territoriality*, *privacy*, and *status* with spatial configuration based on analysis on five layouts of three government organizations. The spatial structure is described with several measures based on axial maps, including integration, connectivity, length of the axial lines, the shape of integration core, the spatial hierarchy based on global and local accessibility defined by integration and connectivity values, the group territoriality, the rank orders of local and global accessibility of space categories, and the degree of congruence between the geometric order and the axial order of a layout. They find that in the organizations that encourage interaction, there are a fewer number of axial lines per workspace and shorter length of axial line per workspace, and higher interconnectedness of the axial structure. The strong territoriality is reflected in space as a well-connected local axial structure that is cut across by fewer axial lines, and has minimal connections with the global structure. The high privacy is achieved through low integration and connectivity of the axial lines on which the space is located and fewer axial lines that cut cross the space. The social status or power difference is reflected on the difference of integration values of the offices of managers and workers. Depending on various organizational cultures, some managers may located in highly segregated space to limit socializations, while some managers may be located in a highly integrated space to have better awareness of overall situation. For instance, the Figure 5.5 shows the old and new layout of case study 2. Based on the axial map analysis, the authors claim that these two layouts are significantly different from one another (Figure 5.6). The old layout demonstrates strong spatial hierarchy and distinctly different staff zones in the axial structure of the layout. By contrast, there is a lack of territoriality and spatial hierarchy with no clear difference between the spatial properties of different spatial categories in

the new layout. The spatial difference of these two layouts are interesting, as the design intention is to use the new layout to increase the amount of interaction and collaboration, reduce power differences, and reduce sense of territoriality. This study is very important for this thesis, as it sets up the foundation of linking organizational constructs with quantitative spatial measures.



**Figure 5.5: (left) The old layout of case study 2, (right) The new layout of case study 2 (Rashid et al., 2003, p. 43.12)**



**Figure 5.6: (left) The axial map of the old layout of case study 2, (right) The axial map of the new layout of case study 2 (Rashid et al., 2003, p. 43.12)**

In a later study on four government office layouts, Rashid et al. (2005) examines both the direct and indirect effect of spatial behaviors and layout attributes on individuals' perception on psychosocial constructs including privacy, communality, communication, control, territoriality, and safety. The spatial measures in this study are integration, connectivity, and length of the axial lines. They discovered that integration is positively related to individuals' perception of community. In other words, workers who sit next to a more integrated space are more likely to have a greater sense of community. Based on a survey questionnaire on 329 employees at four U.S. federal offices, Wineman and Adhya (2007) find the spatial layout of workspace is highly related to the interaction support and sense of community and in turn related to job satisfaction. There is a direct link between the connectivity and interaction support. They also claim that a well-connected local network with high local integration where users could see and reach each other easily is usually a predictor of a strong sense of community.



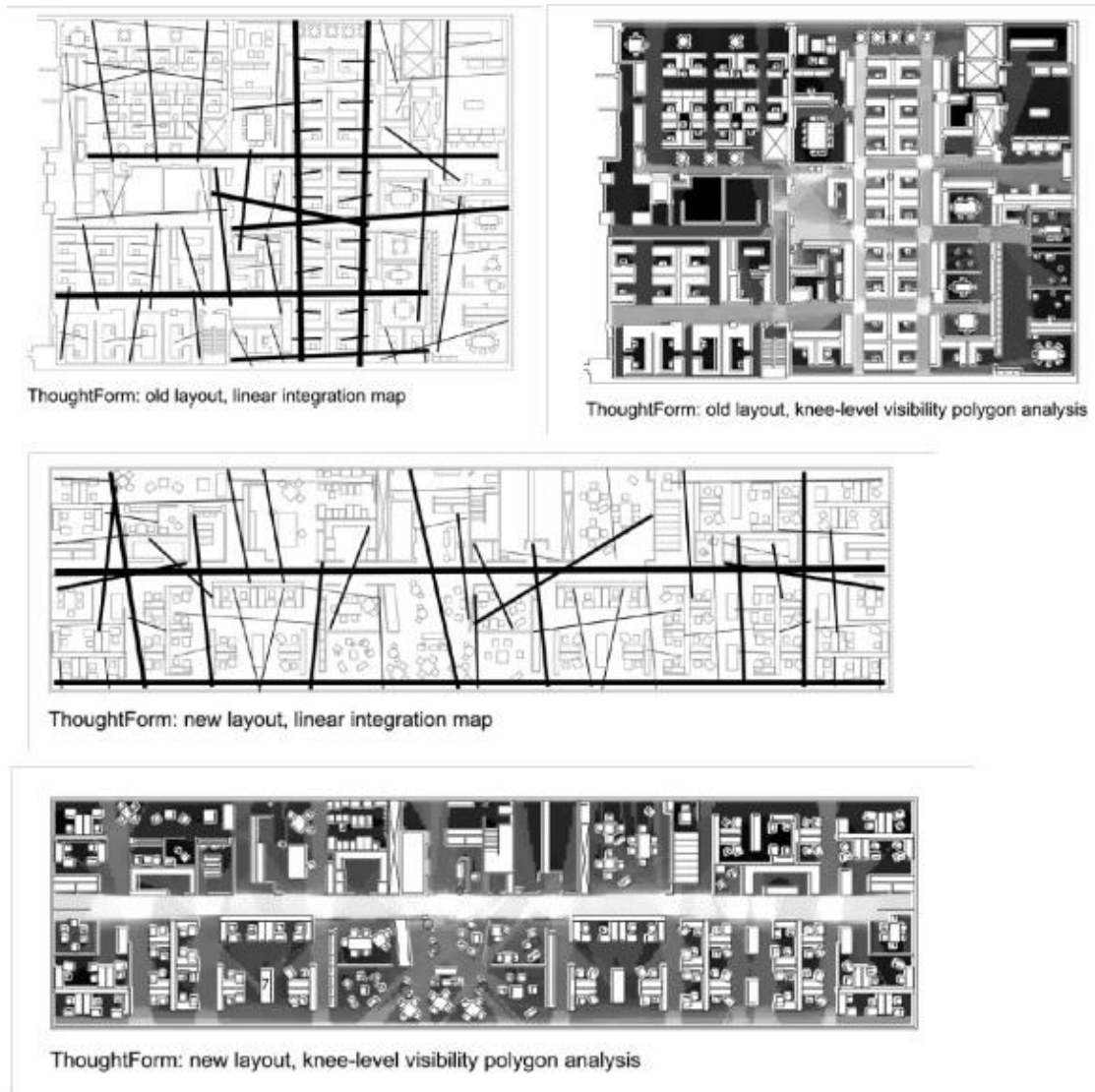
In a study to examine the mechanisms of spatial effects on face-to-face interaction, Rashid et al. (2006) find that visual co-presence instead of movement is the most reliable predictor of face-to-face interaction in offices. More importantly, they reveal the importance of social and cultural aspects of interaction. As they find most interactions occur in individual workspaces, despite the fact that the organizations try to encourage interactions in public spaces by providing public and semi-public spaces. It shows that spatial behaviors such as face-to-face interactions are a product of the interaction between organizational culture and spatial configuration.

Studies have also shown that the changes in the spatial structures of work environment are closely related to the new patterns of organizational behavior, which in turn can lead to or support the transformation of organizational culture (Peponis, et al., 2007; Sailer, Budgen, Lonsdale, Turner, & Penn, 2007; Sailer, et al., 2009). Through a study before and six months after relocation of a UK based radio station, Sailer et al. (2007) find the visual integration and accessibility based on visual graph analysis (calculated using Depthmap) have increased from the old design to the new design. The findings through observation and social network analysis suggest that the increased overall spatial integration may be reflected in increased overall levels of seeing others more frequently and finding them increasingly beneficial. The finding is consistent with those from previous studies.

In a later study, Sailer et al. (2009) add another case that integrates four business units of a large media corporation, which were co-located to one new building. The spatial measure is calculated with the integration value of visual graph. The behavior measures include the movement density based on space observations, and frequency of interaction and usefulness based on questionnaires of social network analysis (SNA). The results demonstrate that the new co-located space has led to new organization behaviors and new organizational cultures of interaction and collaboration. The overall frequency of

face-to-face contact increased slightly (+4%), and collaboration (as measured by the level of mutual usefulness) has increased by 6%. In the new setting, people interact more yet with more concentrated interaction and collaboration partners. There is an increase of the interaction and collaboration across the boundaries of business units.

Peponis et al. (2007) studied a communication design firm, the ThoughtForm, before and after its relocation. The spatial data they collect include the integration and connectivity of axial maps and visual graph (Figure 5.7). They correlate the spatial data with the behavior data collected through self assessment questionnaires and social network analysis (SNA) (Figure 5.8). They discover the new premise with higher integration and connectivity value can contribute to encounter, support unplanned work-related interactions, and thus help spreading specialized knowledge between people with different kinds of expertise, experiences and skills. They further point out that movement across different parts of the layout work as mechanism to generate co-awareness among different ongoing projects, co-workers, and global environment. It facilitates the exchange, reproduction and creation of knowledge. More importantly, there are significant correlations between the integration of the individual's workplace in the new layout and the contribution of the individual to the social network. In other words, the new layout matches better with the interaction network, which makes interaction pattern more intelligible according to space. Thus, the structure of the new space supports its organizational culture.



**Figure 5.7: Axial map and visual graph analysis of old and new office of the ThoughtForm, Peponis et al., 2007, p.830**

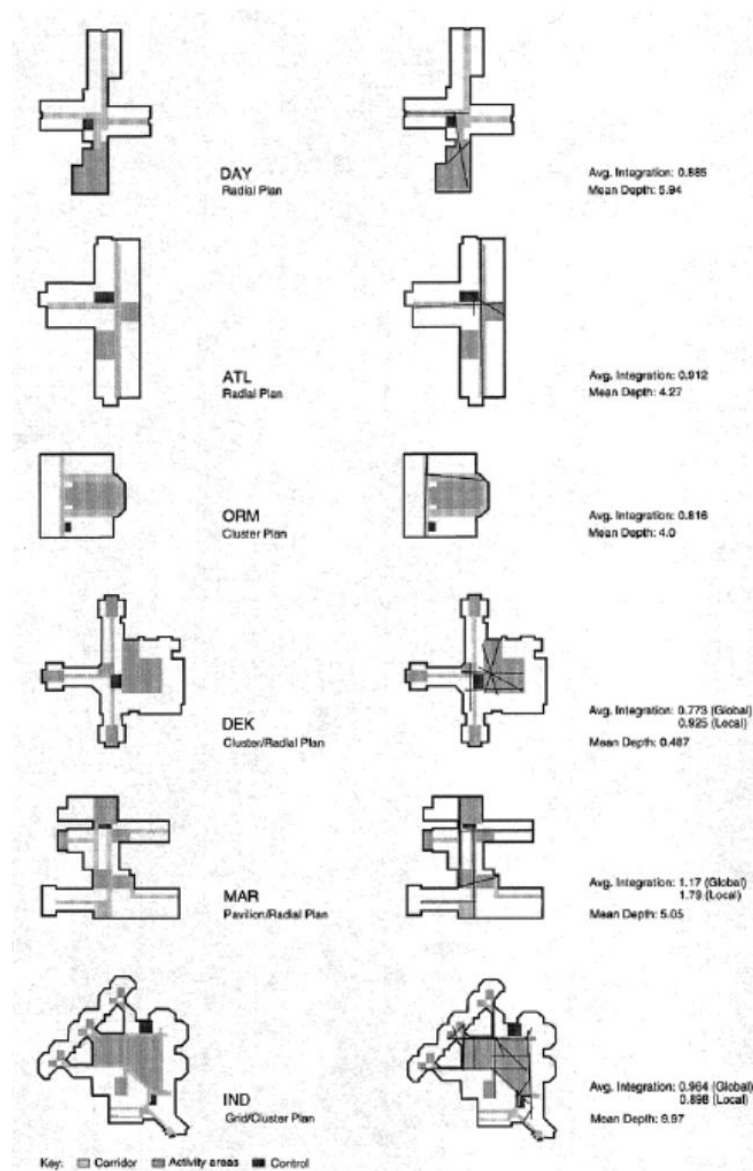
Correlation Matrix	Linear Integration of Workspace Location in		Correlation Between Rankings Before and After Move
	Old Premises	New Premises	
Social hub value	.097 (.51)	.480 (.003)	.489 (.000)
Social gatekeeper value	-.161 (.27)	.471 (.003)	.254 (.028)
Social pulsetaker value	.037 (.08)	.506 (.001)	.494 (.000)
Work hub value	-.081 (.58)	.400 (.014)	.456 (.000)
Work gatekeeper value	-.083 (.57)	.613 (.001)	.322 (.006)
Work pulse-taker value	-.138 (.34)	.327 (.048)	.422 (.000)

Note: Linear Integrations columns reflect Pearson correlation coefficients between descriptors of an individual's position in the social and work networks and the location of the individual's workspace in the layout. The correlation column reflects Kendall correlation coefficients between the rankings of individuals according to network values before and after relocation.

**Figure 5.8: Correlations between social network and space, Peponis, et al., 2007, p. 834**

Most existing space syntax studies are done in weak programmed settings like offices, museums, and labs. The application of space syntax theory in more strongly programmed spaces such as hospital environment is comparatively new. In her studies on three Alzheimer's units and three juvenile detention centers, Peatross (1997) explores the spatial dimensions of control in strong programmed restrictive settings. She correlates the behavior data such as movement and interaction with spatial data, including connectivity and integration of the axial map and the square footage of animated isovist (Figure 5.9). She discovers that the more movement there is, the higher the number of all interactions, and the higher the number of staff to resident interactions. Movement and interaction are configurationally driven---people move and talk where they can be seen by more people. Integration value (1/RRA) correlates consistently across six facilities, with the densities of all, moving, talking, and sitting. Local connectivity correlates the best with behaviors in detention centers, which confirms that detention centers have more localized activities and stronger control of global movement. To achieve the balance between control and social normality, the 10% integration core acts as a domain of

probabilistic encounter and a as a domain of surveillance. As a result, the nurse station is placed either close to the integration core or overlook at the integration core to ensure surveillance. Meanwhile, the activity area or residents' isovist should locate close to or within the integration core to encourage movement and socialization.



**Figure 5.9: Diagrams of three Alzheimer units and three juvenile retention centers and their 10% integration cores (Peatross, 1997, p14.9)**

Hanson and Zako (2005) have studied 36 cases of residential care and nursing homes to explore the relationship between spatial configuration and the quality of life of elder people in those settings. They link the global and local integration of axial map that represent the spatial configurations with the proportion of the residents' active time, frequency of the residents' enjoyable activity, and the extend of the residents' choice and control over environment. The results show that the mean global axial integration of the public realm is positively associated with the proportion of residents' time active, with more integrated buildings leading to residents being active for longer. The mean local axial integration of the public realm is positively associated with residents being engaged more frequently in enjoyable activities and having more choices and control over their local environment.

In a recent study, Hendrich et al. (2009) use space syntax method to re-analyze existing time and motion data in nursing units. They reveal that nurse assignments with higher integration/centrality can lead to greater frequency of nurses' visits to patient rooms and the nurse station. Trzpuc and Martin (2010) analyzed three nursing unit plans, a centralized station with four pods, a centralized station with six pods, and a hybrid station, based on two space syntax concepts, visibility and connectivity. However, their analysis used qualitative descriptions of spatial propensity and failed to establish the correlation between space and nurses' frequency of communication and perceived social support. Lu (2010) developed targeted visibility index (TVI) towards the patient bed. The assessment of three nursing unit designs by TVI aligned exactly with previous empirical evaluations conducted by Trites and his colleagues. Cai and Zimring (2011) developed two spatial metrics based on the concept of step depth in space syntax: team-base distance (TD) and peer distance (PD). They conducted a comparative study of the east and west wing of Emory 2D ICU using these proposed metrics. Integration, TD, and PD were found to have effect on nurses' interaction ratio, and their co-awareness of

patient rooms and peers. For instance, the overall number of room awareness was positively correlated to the global integration value of assigned alcove ( $R=0.715$ ,  $p<0.01$ ). The room awareness ratio was negatively correlated to the visual and metric local PD ( $R=-.604$ ,  $p<0.05$  and  $R=-.644$ ,  $p<0.05$  respectively). The peer awareness was negatively correlated to the metric global PD ( $R=-.698$ ,  $p<0.05$ ). The correlations held true when nurses' length of work experiences were controlled. These studies demonstrate the possibility of using space syntax to study the link between spatial configuration and movement and interaction in health care settings. However, they have not addressed the issue of culture in relation to communication and design of healthcare environment.

#### **5.4 Summary**

This chapter extensively reviews existing space syntax research on the effects of spatial configuration on face-to-face interaction in work environments, such as museums, and more strongly programmed environments such as hospitals and other restrictive settings. The review demonstrates a consistent correlation of the integration of space and the frequency of face-to-face interaction in an organization. More importantly, through the review, it is possible to link organizational constructs such as territoriality, privacy, and status to spatial constructs. However, it is recognized that the connection between space and organizational behavior is not a simple, direct causal relationship. There are complicated reciprocal relations between organizational culture, space and spatial behaviors such as movement and face-to-face interactions. The spatial behaviors are the result of the interaction between culture and space. At the same time, changes in the spatial structures may facilitate change in spatial behaviors, and in turn may lead to the transformation of organizational culture.

The review also aids in deciding which techniques and measures to use for the analysis of genotype of Chinese and the U.S. nursing units, and the effects of nursing unit layout on face-to-face interaction. To examine the "inequality genotype," rank order of

integration values of different categories of spaces in nursing units will be compared, such as the patient zone, staff zone and circulation area. To understand how national cultural differences in group territoriality, privacy, and power differential are reflected in the layout and use of space, it will be necessary to further calculate spatial measures such as the global integration (RRA), local integration (RRA3), connectivity, and length of axial lines. The next chapter will report the results of spatial analysis of the U.S. and Chinese nursing units using the techniques and measures reviewed in this chapter.



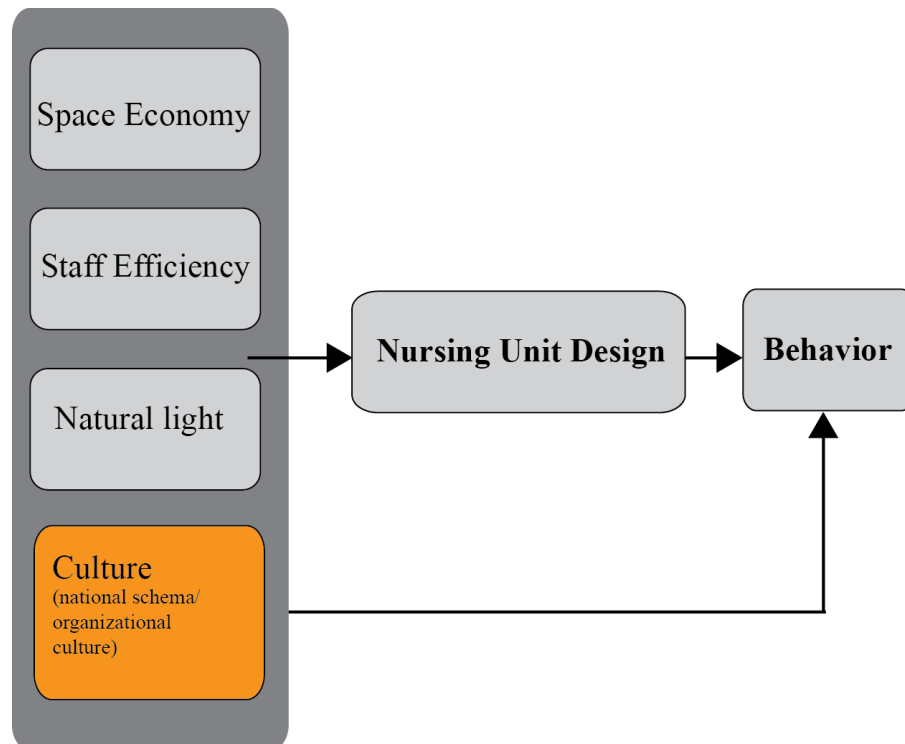
## **SECTION II: EMPIRICAL CASE STUDIES**

## CHAPTER 6

### COMPARATIVE ANALYSIS ON THE U.S. AND CHINESE NURSING UNIT TYPOLOGIES

The theoretical exploration of the first section demonstrated how nursing units design is like a balancing act involving varying levels of influence of several key drivers of Chinese nursing unit design, including space economy, staff efficiency, access to natural light and ventilation, and the cultural needs of face-to-face communication.

Building upon that theoretical exploration, a conceptual model can be developed that links those same four drivers to Chinese inpatient unit design (Figure 6.1). In this model, culture is defined by both national schema and organizational practices. Nursing unit design is seen as the product of the influences of these drivers. Further, communication patterns are not only influenced by culture but also mediated by nursing unit design.



**Figure 6.1 Conceptual model of the interrelationship between key drivers of nursing unit design, space and behavior.**

Based on the conceptual model above, we developed a comparative case study on the U.S. and Chinese nursing unit typologies during the Section II. We firstly selected six U.S. and six Chinese nursing units, each representing an example of one nursing unit typology. Secondly we compared them using the metrics on space economy, staff efficiency, and access to southern light and ventilation, which we have identified in Chapter 2. Efficiency metrics included walking distance measured by furthest distance from nurse station(s) to patient rooms, average distance from nurse station(s) to patient rooms, and average distance from nurse station(s) to patient beds. Economy metrics included corridor length per bed, corridor length per patient room, area per bed, ratio of patient zone, ratio of staff zone, and ratio of circulation area. The metric for access to southern natural light is the ratio of patient beds with southern orientation. Moreover, we used the techniques of both axial map and visual graph analysis (VGA) to describe the patterns of accessibility and visibility of U.S. and Chinese nursing unit typologies. Our focus was to reveal the differences between the U.S. and Chinese nursing unit design, not only related to standard efficiency and economy measures, but also related to the sense of territoriality, hierarchy, and status. Through a careful spatial analysis on the selected nursing unit plans, we uncovered how the cultural differences between the U.S. and China were reflected in the design.

### **6.1 Design of Comparative Study**

A comparative study was designed in order to evaluate the differences of the U.S. and Chinese nursing unit typologies. Three different types of comparisons were made: (1) a comparison of plans of various typologies among the U.S. cases and among Chinese cases; (2) a comparison of the U.S. and Chinese cases with the same typology; and (3) an overall comparison of the U.S. and Chinese cases.

### **6.1.1 The Criteria of Case Selection**

The cases that we compared in this thesis were not selected based on random sampling. They were selected based on two criteria: (1) each case should be representative of one of the six nursing unit typologies that we have identified in Chapter 2; (2) detailed plans were available for reproduction in Autocad to carry out spatial analysis.

The U.S. cases were selected from a range of sources. Some were reproduced based on floor plans from publications including “Healthcare Design Magazine,” “Architectural Record,” and “The Architects’ Journal;” others were CAD files that we obtained from architectural firms. The Chinese cases were selected from various sources including the “The Selected Works of China Hospital Architecture Series 3 (1999-2004),”(CHEA/AHA & CIA/AHA, 2004) “The Design of Modern Hospitals,” (Luo, 2007) some Chinese architectural journals, and CAD files from architectural firms.

For each typical nursing typology, we chose one American example and one corresponding Chinese example (Figure 6.2). For the single corridor typology, the U.S. case selected was the NYU Bellevue Hospital, and the Chinese case was the Shanghai Huashan No. 2 inpatient building. For the double corridor typology, the U.S. example was the St. Joseph Hospital at St Paul, Minnesota, and the Chinese example was the Shanghai First People’s Hospital. For the radial typology, the U.S. case was the Kaiser Foundation Hospital, and the Chinese example was the Chongqin Southwestern Hospital. For the triangular typology, the U.S. example was the Emory Hospital 5E unit, and the Chinese example was the Sichuan Third People’s Hospital. For cluster typology, the U.S. case was the Hasbro Children Hospital, and the Chinese case was the Chengdu TCM Hospital. In addition to the above five common nursing unit typologies that were shared among the U.S. and China, there were some nursing unit typologies that were unique for the U.S. or China. For instance, there was no corresponding Chinese example for the

distributed typology, due to the shortage of nurses and the task-based care model. Hence we chose only one example from the U.S., the Dublin Methodist Hospital. Similarly, the mutated racetrack typology was uniquely Chinese. As we have mentioned in the Chapter 2, the main feature of the mutated racetrack the distinction of public corridor and backstage corridor in the loop circulation system. Hence we selected only one Chinese case, the Shanghai Ruijin Hospital No. 9 inpatient building as the example of the mutated racetrack typology.

The basic information of all cases that we selected is listed in the table follows (Table 6.1). The information includes the nursing unit typology, the region, the name of the hospital, total number of patient beds per nursing unit, number of nurse stations in each nursing unit, number of patient beds per nurse station, number of beds per patient room, gross area, and perimeter of each nursing floor.

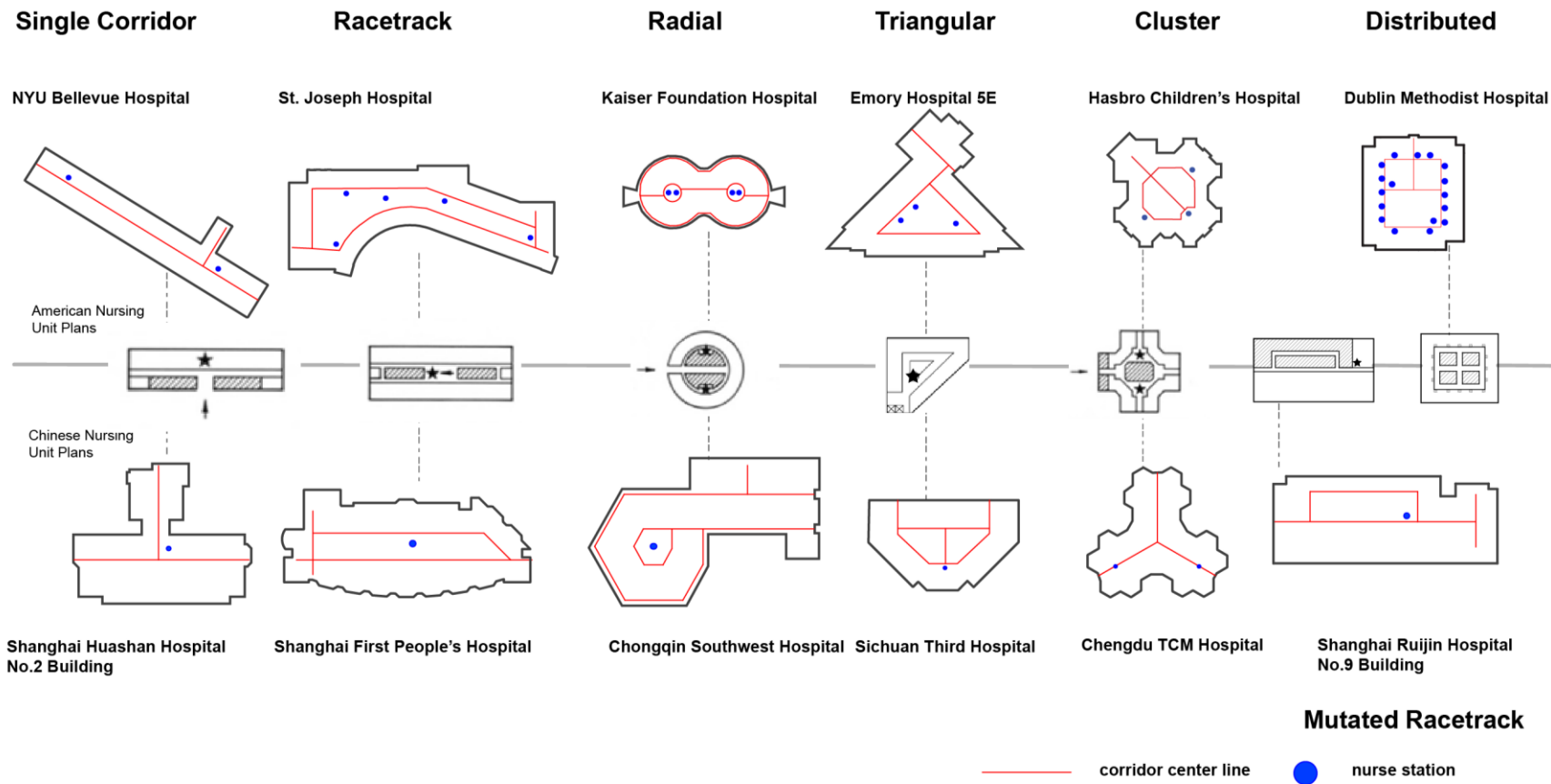


Figure 6.2: Selected U.S. and Chinese cases for nursing unit typologies study

We acknowledge the fact that due to the selection criteria and small sample size, the 12 cases are not meant to represent whole population of the U.S. and Chinese nursing units. And some of the units have different functions, such as children's unit versus adults' unit and regular med-surgical unit versus special care unit, which might confound some of our findings. However, as an initial exploration on the national differences on application of nursing unit typology, the detailed analysis on those plans do allow us to have clear insights on the role of culture on nursing unit designs.

### **6.1.2 Methods for Comparison**

The comparison was based on not only the metrics related to space economy and staff efficiency, but also the spatial metrics that were related to the sense of territoriality, control, and hierarchy.

To evaluate the economy of space usage, we calculated the overall length of corridor center line, the corridor length per bed, the corridor length per patient room, the area per bed, the area and ratio of patient zone, staff zone, and circulation area. The corridor length per patient bed is a value that closely related to the density of beds (James & Tatton-Brown, 1986). The shorter corridor length per bed the more beds can be fitted into certain space. The corridor length per patient room is further calculated, since the difference between this value and the corridor length per bed can demonstrate the impacts of number of beds per room on the compactness of layouts and the space economy. The area and ratio of various functional zones are valid metrics to evaluate the investment efficiency. An economical plan is one in which most space is in use for the maximum number of hours per day and dedicated for patients' needs. Thus, a layout with a large circulation area is considered to be not very economical (James & Tatton-Brown, 1986; Thompson & Goldin, 1975). The calculated results based on the space economy metrics are shown in Table 6.2. To evaluate the possible effects of space on staff efficiency, we calculated the distance from nurse station(s) to the furthest patient room, and the average

distance from nurse station(s) to patient rooms/beds. According to James and Tatton Brown (1986), the average distance from nurse base to patient bed is the yardstick for the staff-patient contact. The distance from nurse station to the furthest patient room is another important metric for evaluating the functional efficiency of a nursing unit (Kobus et al., 2008; Thompson & Goldin, 1975), as it is closely related to the amount of attention that patients may get from caregivers and the response time. A recent research by Hall and others (Hall, Kyriacou, Handler, & Adams, 2008) showed that the predictor of time to initial assessment of chest pain patients in an emergency department was being placed in a room with a door and being placed in a room that was far from the main physician work station (25 feet or more). The *Architectural and Design Code for Chinese General Hospitals* also stated that the distance from the nurse station to the furthest patient room should be no more than 30 meters (98.4 ft) (Ministry of Housing and Urban-Rural Development of the People's Republic of China [MOHURD] , General Administration of Quality Supervision Inspection and Quarantine of the PRC [AQSIQ], & Health Care Architecture Design Committee of Association of Chinese Health Economics, 2004a). Based on these two metrics, the staff efficiency of the layouts are calculated and shown in Table 6.3.

For spatial analysis, we used the techniques of both the visual graph and the axial map analysis. The visual graph analysis was developed by following the steps described below. Firstly, all plans were drawn to the same scale in AutoCAD 2012. Then we exported the plans into DXF files and imported them into the Depthmap 8 to conduct both visual graph and axial map analyses. In Depthmap 8, we overlaid a 1 ft by 1 ft (30 cm by 30 cm) grid on top of each plan. The plans then were represented as certain counts of square tiles. The inter-visibility of those tiles was calculated and visualized by color ranges. In this thesis, we used the color from red to blue to represent values from high to low. For visual graph analysis, we removed all doors, windows, glass partitions, and low



furniture that were below eye level. Therefore the results represented the inter-visibility of the layout. The resulted measures from visual graph included mean connectivity, mean integration of the overall unit (1/RRA), the intelligibility of the layout that is measured by the correlation between connectivity and integration, the mean integration value of nurse station(s), patient zone, staff zone and circulation area, and the rank order of integration values of various zones. The detailed results are reported in Table 6.4.

For axial map analysis, we kept all physical barriers that might prohibit movement and drew the fewest and longest lines that connected all spaces in the layout. Thus, the results of axial map analysis represent the accessibility of a layout and predict patterns of movement. The measured results from axial map analysis included the number of axial lines per space, global integration, the correlation between connectivity and global integration, and the structure of colored axial maps. The detailed results are reported in Table 6.5.

### **6.1.3 Three Levels of Comparisons**

The first level of comparison was among different typologies within the U.S. and Chinese cases. The purpose of this comparison was to examine the impact of typologies on efficiency and economy, with the national difference controlled. The comparison focused on the efficiency and economy of various nursing unit typologies.

The second level of comparison was between the U.S. and Chinese cases with same typology. The purpose was to find out if there was any influence of national difference that was reflected in the design of nursing unit, with the typology controlled constant.

The third level of comparison was an overall comparison between the U.S. and Chinese cases, and to evaluate if any cultural inequality genotype existed.

**Table 6.1: Basic information of the selected cases of the U.S. and Chinese nursing units**

Nursing Unit Typology	Region	Hospital	Year	# Beds	# NS	# PR	Beds/NS	Beds/ PR	Gross Area (sq ft)	Perimeter (ft)	Ratio_0.51patient beds with southern light
Single Corridor	USA	NYU Bellevue Medical Center	1948	67	2	28	33.5	2.4	21637	981	79%
	China	Shanghai Huashan Hospital No.2 Building	1986	43	1	9	43.0	4.8	9318	550	100%
Racetrack/ Double corridor	USA	St. Joseph's Hospital	2005	45	5	45	9.0	1.0	41929	1146	51%
	China	Shanghai No.1 People's Hospital	2000	43	1	20	43.0	2.2	19060	683	70%
Radial	USA	Kaiser Foundation	1960	46	2	22	23.0	2.1	15876	602	48%
	China	Chongqin SouthWest Hospital	1990	19	1	10	19.0	1.9	10043	521	53%

**Table 6.1: Basic information of the selected cases of the U.S. and Chinese nursing units (continued)**

<b>Nursing Unit Typology</b>	<b>Region</b>	<b>Hospital</b>	<b>Year</b>	<b># Beds</b>	<b># NS</b>	<b># PR</b>	<b>Beds/NS</b>	<b>Beds/PR</b>	<b>Gross Area (sqft)</b>	<b>Perimeter (ft)</b>	<b>Ratio patient beds with southern light</b>
Triangular	USA	Emory Hospital 5E	2001	20	3	20	6.7	1.0	15296	548	30%
	China	Sichuan Third Hospital	1990	34	1	14	34.0	2.4	16918	522	82%
Cluster	USA	Hasbro Children`s Hospital	1994	30	3	24	10.0	1.3	34463	959	57%
	China	Chengdu TCM University Affiliated Hospital	1990	49	2	25	24.5	2.0	12639	683	65%
Distributed	USA	Dublin Methodist	2007	20	14	20	1.4	1.0	15552	596	20%
Mutated Racetrack	China	Shanghai Ruijin Hospital No.9 Building	2005	39	1	13	39.0	3.0	14190	563	100%

**Table 6.2: Comparison on space economy measures on selected the U.S. and Chinese nursing unit layouts**

<b>Nursing Unit Typology</b>	<b>Region</b>	<b>Hospital</b>	<b>Corridor Center Line Length (ft)</b>	<b>Corridor Length ft/#beds</b>	<b>Corridor Length ft/#rooms</b>	<b>Area/bed (sqft)</b>	<b>PatientZone_Ratio</b>	<b>StaffZone_Ratio</b>	<b>Circulation_Ratio</b>
Single Corridor	USA	NYU Bellevue Medical Center	385	6	14	323	50%	18%	32%
	China	Shanghai Huashan Hospital No.2 Building	213	5	24	217	34%	21%	45%
Racetrack	USA	St. Joseph's Hospital	825	18	18	932	42%	29%	29%
	China	Shanghai No.1 People's Hospital	488	11	24	443	51%	21%	28%
Radial	USA	Kaiser Foundation	502	11	23	345	41%	8%	51%
	China	Chongqin SouthWest Hospital	510	27	51	529	28%	31%	41%

**Table 6.2: Comparison on space economy measures on selected U.S. and Chinese nursing unit layouts (continued)**

<b>Nursing Unit Typology</b>	<b>Region</b>	<b>Hospital</b>	<b>Corridor Center Line Length (ft)</b>	<b>Corridor Length ft/#beds</b>	<b>Corridor Length ft/#rooms</b>	<b>Area/bed (sqft)</b>	<b>PatientZone_Ratio</b>	<b>StaffZone_Ratio</b>	<b>Circulation_Ratio</b>
Triangular	USA	Emory Hospital 5E	803	40	40	765	44%	17%	46%
	China	Sichuan Third Hospital	670	20	48	498	45%	22%	33%
Cluster	USA	Hasbro Children`s Hospital	732	24	31	1149	40%	34%	26%
	China	Chengdu TCM University Affiliated Hospital	320	7	13	258	45%	23%	32%
Distributed	USA	Dublin Methodist	485	24	24	733	53%	16%	31%
Mutated Racetrack	China	Shanghai Ruijin Hospital No.9 Building	409	10	31	364	44%	28%	28%

**Table 6.3: Comparison on staff efficiency measures on selected U.S. and Chinese nursing unit layouts**

<b>Nursing Unit Typology</b>	<b>Region</b>	<b>Hospital</b>	<b>Furthest NS-PR (ft)</b>	<b>Ave Distance NS-PR (ft)</b>	<b>Ave Distance NS-Bed(ft)</b>
Single Corridor	USA	NYU Bellevue Medical Center	140	55	23
	China	Shanghai Huashan Hospital No.2 Building	57	32	7
Racetrack	USA	St. Joseph's Hospital	51	26	26
	China	Shanghai No.1 People's Hospital	87	47	22
Radial	USA	Kaiser Foundation	28	19	9
	China	Chongqin SouthWest Hospital	22	17	9

**Table 6.3: Comparison on staff efficiency measures on selected U.S. and Chinese nursing unit layouts (continued)**

<b>Nursing Unit Typology</b>	<b>Region</b>	<b>Hospital</b>	<b>Furthest NS-PR (ft)</b>	<b>Ave Distance NS-PR (ft)</b>	<b>Ave Distance NS-Bed(ft)</b>
Triangular	USA	Emory Hospital 5E	50	27	27
	China	Sichuan Third Hospital	93	58	24
Cluster	USA	Hasbro Children`s Hospital	32	25	20
	China	Chengdu TCM University Affiliated Hospital	24	19	10
Distributed	USA	Dublin Methodist	21	19	19
Mutated Racetrack	China	Shanghai Ruijin Hospital No.9 Building	100	45	15

**Table 6.4: Visual Graph Analysis on selected U.S. and Chinese nursing unit layouts**

Nursing Unit Typology	Region	Hospital	Total counts	Mean Connectivity	Mean Integration	R2*	NS integration	Patientzone Integration	Staffzone Integration	Circulation Integration
Single Corridor	USA	NYU Bellevue Medical Center	18812	1192.190	7.133	0.932	7.954	6.049	5.956	9.775
	China	Shanghai Huashan Hospital No.2 Building	8158	604.803	6.147	0.803	8.127	5.481	5.290	7.124
Racetrack	USA	St. Joseph's Hospital	36718	982.383	5.024	0.684	5.845	4.452	4.776	5.862
	China	Shanghai No.1 People's Hospital	18090	1056.740	6.839	0.881	8.943	6.326	6.391	8.379
Radial	USA	Kaiser Foundation	12653	646.568	6.176	0.802	9.230	5.700	7.451	6.468
	China	Chongqin SouthWest Hospital	8883	602.184	6.217	0.762	8.553	5.503	5.775	7.007



**Table 6.4: Visual Graph Analysis on selected U.S. and Chinese nursing unit layouts (continued)**

<b>Nursing Unit Typology</b>	<b>Region</b>	<b>Hospital</b>	<b>Total counts</b>	<b>Mean Connectivity</b>	<b>Mean Integration</b>	<b>R2 (connectivity vs. global integration, <math>p &lt; 0.0001</math>)</b>	<b>NS integration</b>	<b>Patient zone Integration</b>	<b>Staff zone Integration</b>	<b>Circulation Integration</b>
Triangular	USA	Emory Hospital 5E	13889	1532.410	8.400	0.879	10.739	7.160	7.749	8.186
	China	Sichuan Third Hospital	15467	593.140	5.102	0.781	7.525	4.536	5.401	5.652
Cluster	USA	Hasbro Children's Hospital	29494	782.651	4.785	0.714	5.570	4.286	4.940	6.116
	China	Chengdu TCM University Affiliated Hospital	11004	529.430	4.860	0.703	6.545	4.287	5.423	5.619
Distributed	USA	Dublin Methodist	13984	917.281	6.618	0.799	7.626	5.948	6.615	8.013
Mutated Racetrack	China	Shanghai Ruijin Hospital No.9 Building	12656	619.049	5.841	0.844	7.842	5.525	4.753	7.335

**Table 6.5: Axial map analysis on selected U.S. and Chinese nursing unit layouts**

<b>Nursing Unit Typology</b>	<b>Region</b>	<b>Hospital</b>	<b>No. Axial lines per space</b>	<b>Axial mean connectivity</b>	<b>Axial mean Global integration</b>	<b>R2 (connectivity vs. global integration, <math>p&lt;0.0001</math>)</b>
Single Corridor	USA	NYU Bellevue Medical Center	0.905	2.116	1.856	0.603
	China	Shanghai Huashan Hospital No.2 Building	0.729	4.229	2.479	0.910
Racetrack	USA	St. Joseph's Hospital	0.974	2.265	1.446	0.535
	China	Shanghai No.1 People's Hospital	0.731	4.807	2.520	0.782
Radial	USA	Kaiser Foundation	1.103	3.147	1.521	0.623
	China	Chongqin SouthWest Hospital	0.857	3.429	1.523	0.625

**Table 6.5: Axial map analysis on selected U.S. and Chinese nursing unit layouts (continued)**

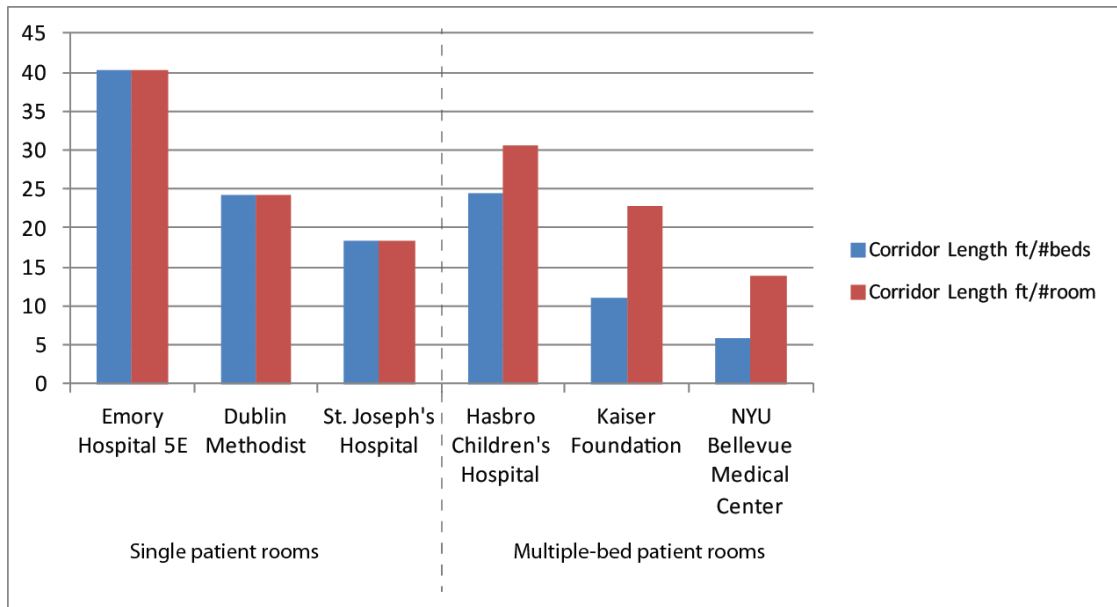
<b>Nursing Unit Typology</b>	<b>Region</b>	<b>Hospital</b>	<b>No. Axial lines per space</b>	<b>Axial mean connectivity</b>	<b>Axial mean Global integration</b>	<b>R2 (connectivity vs. global integration, <math>p &lt; 0.0001</math>)</b>
Triangular	USA	Emory Hospital 5E	1.091	4.700	1.956	0.715
	China	Sichuan Third Hospital	0.957	3.455	1.515	0.685
Cluster	USA	Hasbro Children`s Hospital	0.757	3.062	1.048	0.543
	China	Chengdu TCM University Affiliated Hospital	0.603	3.314	1.256	0.605
Distributed	USA	Dublin Methodist	0.804	2.311	1.290	0.845
Mutated Racetrack	China	Shanghai Ruijin Hospital No.9 Building	0.838	3.774	2.037	0.722

## **6.2 Comparison of Various Typologies among the U.S. and Chinese Cases**

In this section, we report the results of comparison of various typologies among the U.S. and Chinese cases.

### **6.2.1 Space Economy Comparison of the U.S. Nursing Units Typologies**

For the overall length of the corridor center line, the double corridor layout had the largest value (825 ft), followed by the triangular (803 ft), the cluster (732 ft), the radial (502 ft), the distributed (485 ft), and the single corridor (385 ft). When we divided the overall corridor length by number of patient rooms, then the triangular layout (40 ft) had the largest corridor length per patient room, followed by the cluster (31 ft), the distributed (24 ft), the radial (23 ft), the racetrack (18 ft), and the single corridor (14 ft). When we divided the overall corridor length by the number of patient beds, then the triangular layout (40 ft) had the largest corridor length per patient bed, followed by the cluster (24 ft) and the distributed (24 ft), the racetrack (18 ft), the radial (11 ft), and the single corridor (6 ft) (Table 6.2). It seems that the nursing unit typologies with redundant compound circulation are less economical than those with simple circulation themes (Figure 6.3). For nursing units with simple circulation, such as single corridor layout, less length of corridor is needed to connect all spaces.

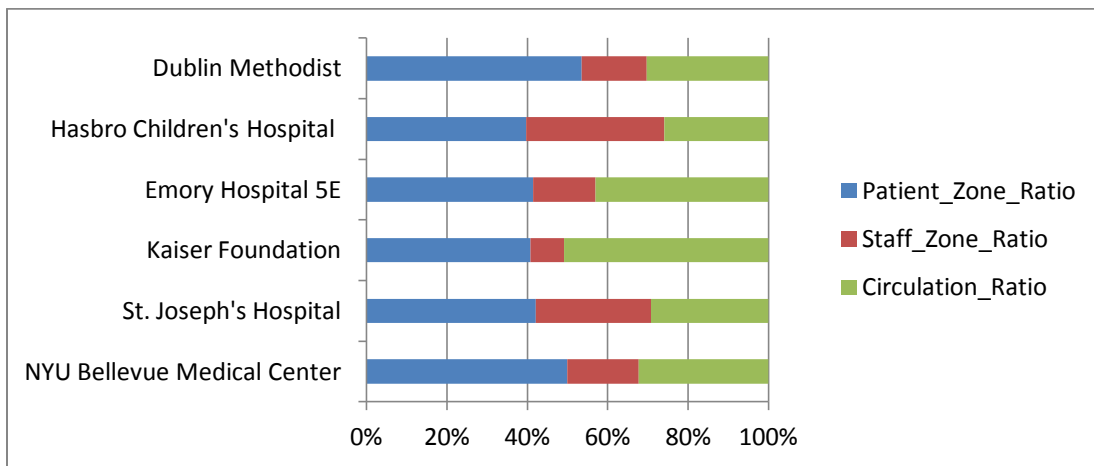


**Figure 6.3: Comparison of the corridor length per patient room and corridor length per bed in the U.S. nursing units**

We further used area per bed as the unit of analysis. The cluster layout had the largest area per bed (1149 sq ft), followed by the racetrack layout (932 sq ft), the triangular layout (765 sq ft), the distributed layout (733 sq ft), the radial layout (345 sq ft). And the single corridor layout had the smallest area per bed (323 sq ft). The reason that the cluster layout had the largest area per bed because of the separation of one unit into two sub-clusters increased the area of circulation and support zone.

When we considered the composition of patient zone, staff zone and circulation, the distributed layout had the largest proportion of patient zone (53%), and the single corridor layout had the second largest proportion of patient zone (50%). By contrast, the cluster layout had the smallest proportion of patient zone (40%) for the same reason that we have explained above. It seems that the distributed layout and the single corridor are economically sounder than other layouts, as the construction cost is well spent on the patient area. For staff zone, the radial layout had the smallest proportion of area for staff use (8%), due to the limited area of service core constrained by the shape of radial layout.

The cluster layout and the racetrack layout had comparatively large staff zone, 34% and 29% respectively. The larger staff zone in the cluster layout can be attributed to the additional staff work area required when having separate care teams in two sub-units. For the case of the racetrack design, the increased depth of the layout allows larger staff support zone to be located in the middle of the unit. In terms of the circulation area, the radial layout had the largest proportion of circulation area (51%), followed by the triangular layout (46%). The cluster layout had the smallest proportion of circulation area (26%) (Figure 6.4). It shows that although the cluster layout has larger staff zone and sacrifices some area for patient zone, it does have the benefits of reducing circulation and moving care givers closer to patients.



**Figure 6.4: Comparison of the composition of different functional zones in the U.S. nursing units**

Overall, when we compared designs with multiple-bed patient rooms, the single corridor layout was most economical, as in the case of NYU Bellevue Medical Center. It had the shortest corridor length per bed and smallest area per bed. When only designs with single patient rooms were considered, the racetrack layout had the smallest corridor length per bed. In terms of area per bed and composition of various functional zones, the

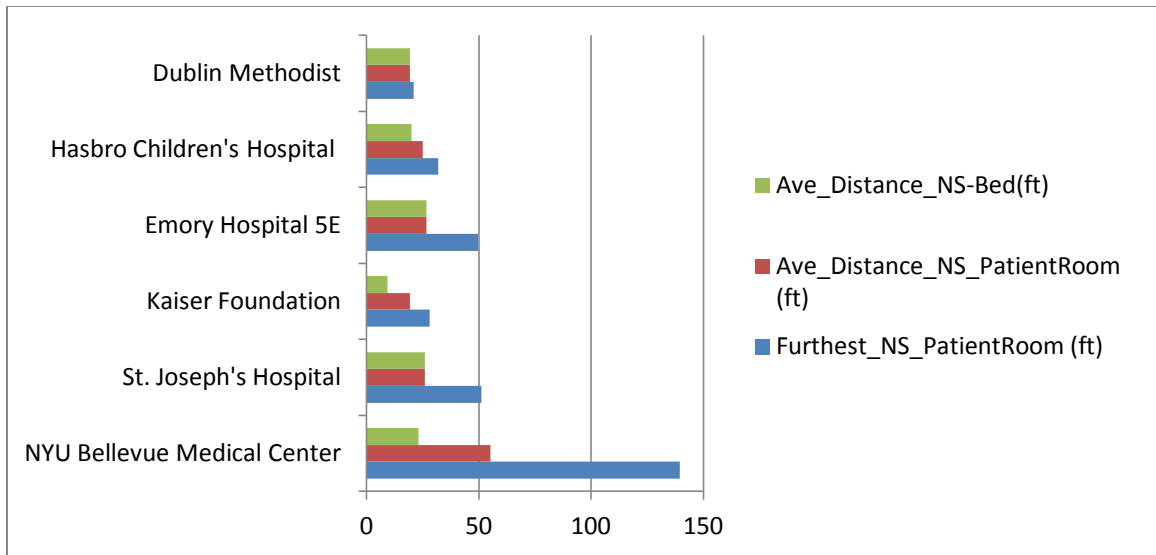
distributed layout seemed to be the most economically sound design (Figure 6.4). In the example of the distributed layout, i.e. the Dublin Methodist Hospital, staff work areas were broken down into small alcoves and perching stations located within circulation area, which saved a large amount of footprint in addition to moving caregivers closer to patients.

However, the value of single-bed rooms has been acknowledged by the AIA after extensive research and has been included in the *2006 Guidelines for Design and Construction of Health Care Facilities* (AIA & FGI, 2006). Single patient rooms are required in all new hospital construction in the U.S. We expect the transition from multiple beds patient rooms to single rooms to have great impacts on performance related to space economy.

### **6.2.2 Staff Efficiency Comparison of the U.S. Nursing Units Typologies**

The efficiency measures focused on examining the possible effects of the layout on nurses' walking distance. Three measures were applied, the furthest distance from nurse station to patient room, the average distance from nurse station to patient rooms, and the average distance from nurse station to patient beds. The single corridor layout had the largest distance from the nurse station to the furthest patient room (140 ft). The distributed layout had the shortest distance from the nurse station to the furthest patient room (21 ft), followed by the radial layout (28 ft). It shows that patients in the distributed layout and the radial layout get more equal attention from nurse station. By contrast, some patients in the example of the single corridor layout were quite remote to the nurse station, thus they might feel isolated and less attended. For the average distance from nurse station to patient rooms, again the single corridor layout had the largest distance (55 ft), while the distributed layout and the radial layout had the shortest distance (19 ft). When we considered number of beds in each patient room, then the single corridor layout with multiple beds became more efficient, comparing to the racetrack layout and

triangular layout with single bed. It shows that efficiency is related not only to the nursing unit typologies, but also the number of beds per patient room. Overall, the distributed layout and the radial layout are considered as more efficient design when compared to other nursing unit typologies (Figure 6.5).



**Figure 6.5: Comparison of efficiency of the U.S. nursing units**

### 6.2.3 Spatial Analysis on the U.S. Nursing Units Typologies

For visual graph analysis, the example of the triangular layout had the highest value of mean visual connectivity and mean visual integration, followed by the single corridor layout. Moreover, both the triangular and single corridor layout had a high correlation between the connectivity and global integration values, which demonstrated that both layouts had intelligible configurations. The example of the cluster layout had the lowest mean integration value, which showed that the configuration had low visual interconnectedness and fewer opportunities for movement and interaction at the global scale. The nurse stations in the triangular layout had the highest integration value, followed by the radial layout. The location of the nurse stations in these layouts might



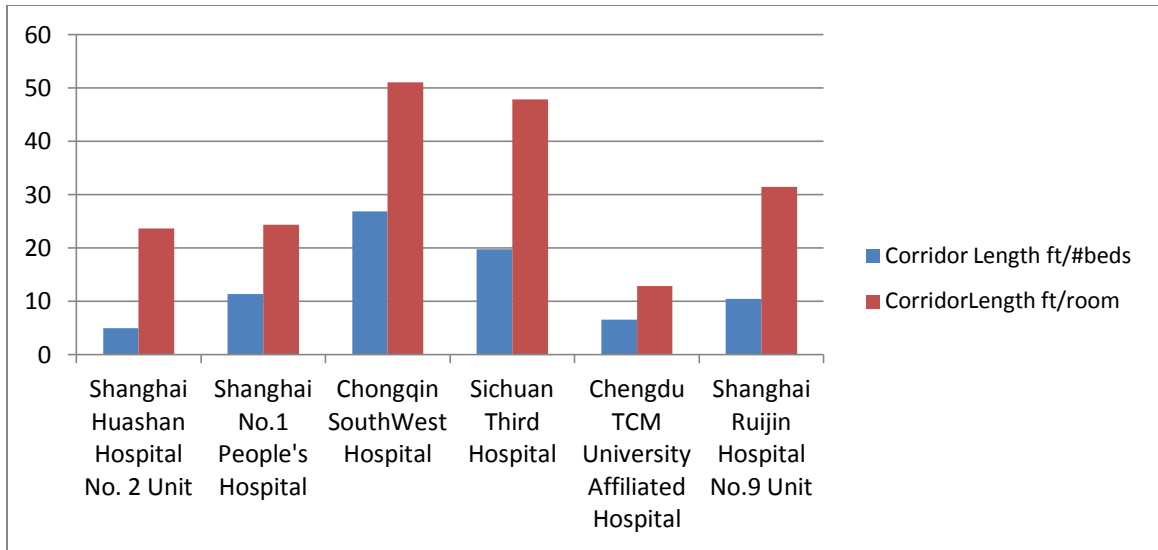
allow nurses to have a good awareness of the overall nursing unit and have a high potential of informal communication. Among the six typologies, the circulation in the single corridor layout had the highest integration value, while the one in the racetrack layout had the lowest mean integration value.

For axial map analysis, the case of the triangular layout again had the highest value of axial mean connectivity and mean global integration. The case of the single corridor has the second highest value of mean axial integration yet the lowest mean axial connectivity. The distributed layout was the most intelligible layout in terms of accessibility with the highest correlation between axial connectivity and integration, followed by the triangular layout.

It seems that the case of the triangular layout is highly inter-connected both visually and physically at the local and global scale. It indicates that the configuration of the triangular layout encourages more cross-disciplinary communications.

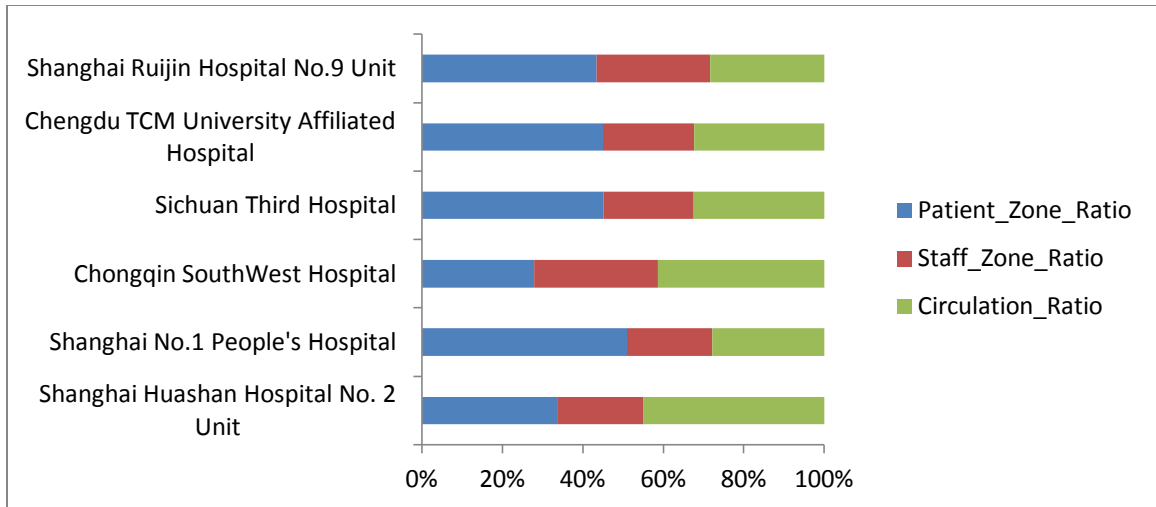
#### **6.2.4 Economy Comparison of Chinese Nursing Units Typologies**

For the six cases of Chinese nursing units, the radial layout had the largest corridor length per patient room (51 ft), followed by the mutated racetrack (31 ft), the triangular layout (26 ft), the racetrack layout (24 ft), the single corridor layout (24 ft), and the cluster layout (13 ft). All Chinese cases had multiple beds in patient rooms. When we further calculated the corridor length per patient bed, the radial layout still had the largest corridor length per bed (27 ft), while the cluster layout and the single corridor layout had much smaller corridor length per bed, 7 ft and 5 ft respectively. The result aligns with what we discovered earlier from the U.S. cases. Most typologies with redundant compound circulations tend to have larger corridor length per patient room than those with simple circulation systems (Figure 6.6).



**Figure 6.6: Comparison of the corridor length per patient room and corridor length per bed in Chinese nursing units**

When we calculated the space area, the radial layout had the largest area per bed (529 sq ft), followed by the triangular layout (498 sq ft), the racetrack layout (443 sq ft), the mutated racetrack (364 sq ft), the cluster layout (258 sq ft), and the single corridor layout (217 sq ft). The result again corresponds with the one from the U.S. cases that the single corridor has the smallest area per patient bed. In terms of composition of different function zones, the racetrack layout has the largest proportion of patient zone (51%) while the radial layout has the smallest proportion of patient zone (28%). For circulation area, the single corridor layout has the largest proportion (45%), whereas the racetrack layout and the mutated racetrack layout have the smallest proportion (28%) (Figure 6.7).



**Figure 6.7: Comparison of the composition of different functional zones in Chinese nursing units**

Overall the cluster layout and mutated racetrack layout in Chinese nursing units are quite economical, as they have relatively small corridor length per patient bed, small area per patient bed, large proportion of patient zone and small proportion of circulation area. It might be part of the reason that mutated racetrack layout has become more and more popular in China. We assume that with the care model shifting towards patient-centered care and team-based nursing model, the cluster layout will be more widely applied in the future. The analysis also reveals the reason why the single corridor layout is currently the most common typology in China, since it has the smallest corridor length per bed and area per bed. However, we have to recognize that the single corridor layout works best at the current situation when most patient rooms have multiple patient beds. Most single corridor layouts in China are single loaded with most patient rooms facing south. With the rising needs for privacy and more cautions regarding cross infection, there will be an increasing number of single rooms or double rooms in Chinese nursing units. Then the single-loaded single corridor layout will become troublesome, as both the corridor length per bed and the area per bed will increase greatly.

### 6.2.5 Staff Efficiency Comparison of Chinese Nursing Units Typologies

When we considered the efficiency based on nurses' walking distance, the radial layout had the smallest distance from the nurse station to the furthest patient room (22 ft), the smallest average distance from nurse station to patient rooms (17 ft), and relatively small average distance from nurse station to patient beds (9 ft). The cluster layout also had relatively small average distance from nurse station to patient rooms (19 ft) and reasonable relationship between the nurse station and the furthest patient room. The triangular layout, the racetrack, and the mutated racetrack layout had quite large average distance between nurse station and patient rooms (Figure 6.8). These results seem to be inconsistent with those from the U.S. cases. The inconsistency is due to the fact that when compound loop circulations are applied in those Chinese units, the corridors are single loaded with most patient rooms facing south. Arranging patient rooms along only one side of corridors offsets the efficiency of having a compound circulation system.

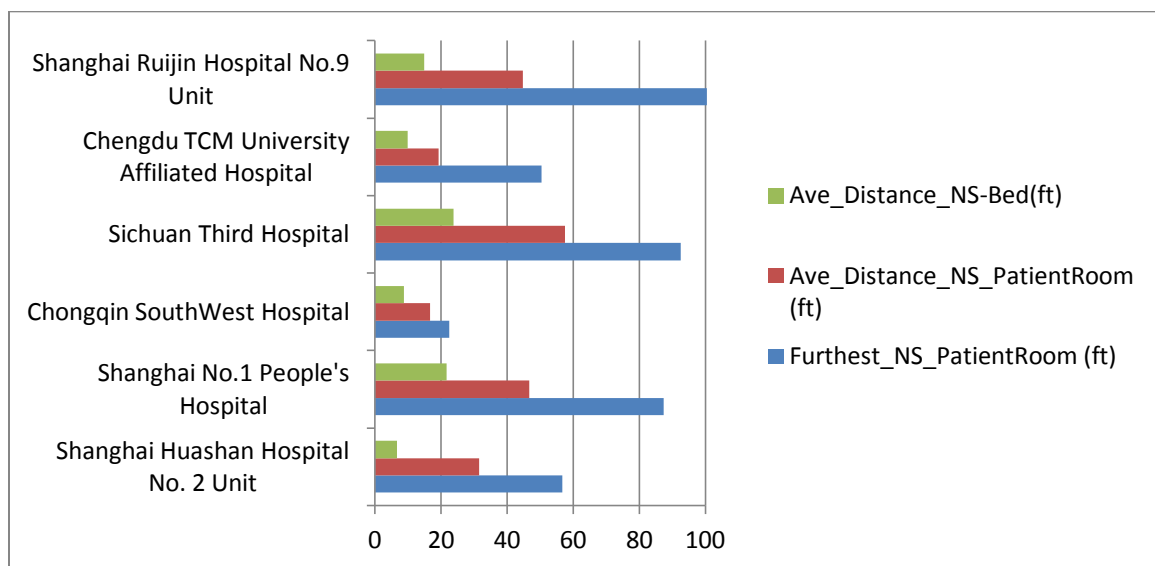


Figure 6.8: Comparison of efficiency of Chinese nursing units

### 6.2.6 Spatial Analysis on Chinese Nursing Units Typologies

For visual graph analysis, the racetrack layout had the highest mean connectivity, mean integration, the strongest correlation between the connectivity and integration. The

nurse station in the racetrack layout had the highest integration value, followed by the radial layout. For all six cases, the circulation area always had the highest integration comparing to the staff zone and the patient zone. The circulation area in the racetrack layout had the highest integration and the one in the mutated racetrack layout had the second highest integration value among the six cases.

For axial map analysis, the racetrack layout again had the highest axial mean connectivity and mean integration, while the cluster had the lowest axial mean connectivity and mean integration value. For the intelligibility of the configuration, the single corridor layout ranked the highest, followed by the racetrack layout.

#### **6.2.7 Summary of the First Level Comparison**

The results from our analysis on staff efficiency of nursing units were consistent with prior studies on nurses' walking distance (Shepley & Davies, 2003; Sturdavant, 1960; Trites, et al., 1970). For both the U.S. and Chinese cases, the radial layout was the most efficient design with the shortest average distance from nurse station to patient rooms.

In terms of space economy, layouts with simple circulation have smaller corridor length per room and per bed. Besides typology, number of beds per room or room density impacts both space economy and staff efficiency. For instance, owing to the arrangement of multiple-bed patient rooms, the examples of single corridor layouts from both countries had the smallest corridor length per bed and quite small average distances from nursing stations to patient beds.

In addition, similar to what Thompson and Goldin (1975) have claimed in their Yale traffic study, we found that economy and efficiency measures did not agree with one another. Each measure focused on a specific aspect of nursing unit design. For instance, in both countries, the radial layout ranked low regarding the economy measures such as corridor length, area per bed, and ratio of patient zone.

### **6.3 Comparison of the U.S. and Chinese Cases with the Same Typology**

In this section, we paired the U.S. and Chinese cases with the same nursing unit typology and compared the measures on economy, efficiency, and spatial properties. The side-by-side comparison allowed us to uncover whether there were different spatial strategies in applying same nursing unit typology in these two countries.

#### **6.3.1 Comparison of the U.S. and Chinese cases with the Single Corridor Layout**

##### **6.3.1.1 Space Economy Measures**

Both the NYU Bellevue Medical Center and the Shanghai Huashan Hospital No.2 Building were based on the single corridor layout. The U.S. case had much smaller corridor length per patient room when compared to the Chinese case, 14 ft and 24 ft respectively. However when we divided the corridor length by number of beds, the Chinese case had shorter length than that of the U.S. case. In addition, the Chinese case had smaller area per bed (217 sq ft) than the U.S. case (323 sq ft). It shows that the Chinese case is more economical in terms of construction area and the corridor length. However the distribution of functional zones in the Chinese case was less economical when compared to the U.S. case (Figure 6.9, Figure 6.10). In the Chinese case, the patient zone accounted for 34% of the total area while the circulation area accounted for 45% of the total area.

##### **6.3.1.2 Staff Efficiency Measures**

When we compared the walking distance from nurse station to patient rooms, we found that the U.S. single corridor layout had larger average distance from the nurse station to patient rooms and to the patient beds than that of the Chinese case, 55 ft versus 32 ft and 23 ft versus 7 ft respectively. Additionally, the furthest patient room was much further away from the nurse station in the case of NYU Bellevue Medical Center (140 ft)

than in the case of Shanghai Huashan Hospital No. 2 building (57 ft). The difference could be attributed to the arrangement of patient zone and the location of the nurse station. The Chinese case, i.e. the Shanghai Huashan Hospital No.2 Building had a much more compact patient zone than the U.S. case, i.e. the Bellevue Medical Center. In addition, the nurse station in the Chinese case was located at the middle of the corridor to achieve the shortest nurses' walking distance.

#### 6.3.1.3 Spatial Analysis

We further conducted the visual graph analysis and axial map analysis. Although both cases were based on shallow floor plate and single corridor layouts, they displayed some interesting differences in terms of visual and physical inter-connectedness.

##### *Visual Graph Analysis*

For the visual graph analysis, the NYU Bellevue Medical Center had larger mean connectivity and larger mean integration values than the Shanghai Huashan Hospital, 1192.190 versus 604.803 and 7.133 versus 6.147 respectively. It shows that the space at the NYU Bellevue Medical Center is better connected visually, both at the local and global scale. Both layouts had strong correlation between the connectivity and the integration value, which suggested that both spatial configurations had intelligible local and global orders.

These two layouts utilized different spatial strategies in the staff work areas. In the case of the NYU Bellevue Medical Center, there were two separate nurse stations and utility rooms, with shared treatment room, staff area, service room and lab at the center of the layout. By contrast, in the Shanghai Huashan Hospital No.2 Building, the care team was co-located in a zone that was composed of nurse station, treatment room, medication room and doctors' office. The adjacency between nurse station and doctors' office seems to be a strategy to facilitate nurse-doctor communication. In addition, in the Huashan

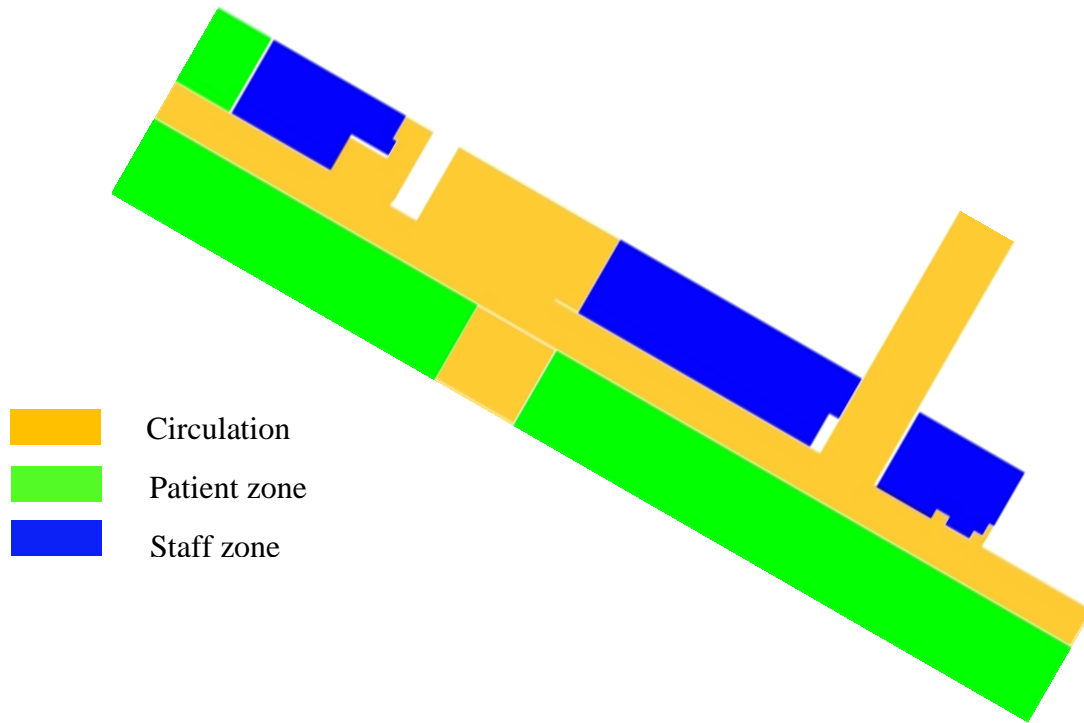
Hospital, the doctors' offices were located deeper in to the layout with lower integration value (4.841) when compared to the nurse station and the treatment room (5.981). In the NYU Bellevue Medical Center, there was no designated doctors' office. Moreover, the difference between the nurse station and the staff office was way smaller (6.373 versus 5.809). The comparison demonstrates that the Chinese case has stronger sense of hierarchy and status. In both cases, the circulation area had the highest integration value. However in the NYU Bellevue Medical Center, the integration value was much higher than the one in the Huashan Hospital (9.775 versus 7.124). In both the U.S. and Chinese cases, staff was located deeper in to the layout and in a less integrated space when compared to patient rooms (5.956 versus 6.049 and 5.290 versus 5.481). Nurse stations in both cases were located in a highly integrated area, yet with quite different strategies. The nurse stations in the NYU Bellevue Medical Center were located close to the highly integrated corridor overlooking patient rooms. By contrast, the nurse station in the Huashan Hospital was located near the integration core at the intersection of two corridors, with the purpose of controlling the in-and-out traffic (Figure 6.11, Figure 6.12).

### *Axial Map Analysis*

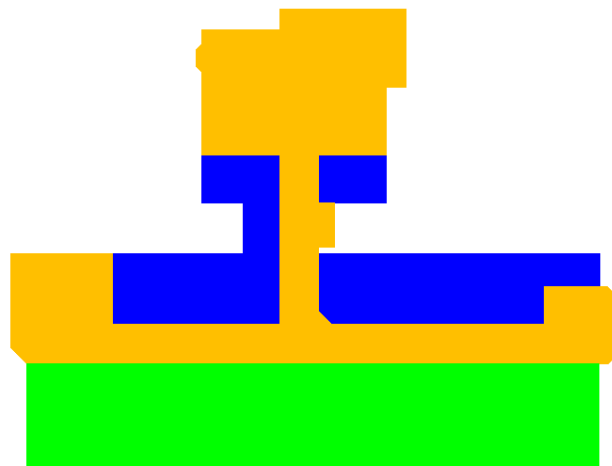
Our findings from the axial map analysis suggested that the patterns of interrelationship of the axial lines were similar in these two layouts, yet with some intriguing differences (Figure 6.13, Figure 6.14). Both cases were based on a T-shape primary order corridor. The more integrated west-east corridor connected all patient rooms and staff work areas, and the less integrated south-north corridor linked the patient and staff zone to the vertical circulation. In addition, both cases had very strong correlation between the connectivity and global integration values. According to Penn and Hillier (1992), the local to global integration interface is a strong predictor of "useful" inter-group communication. We can assume then, that both cases have weak



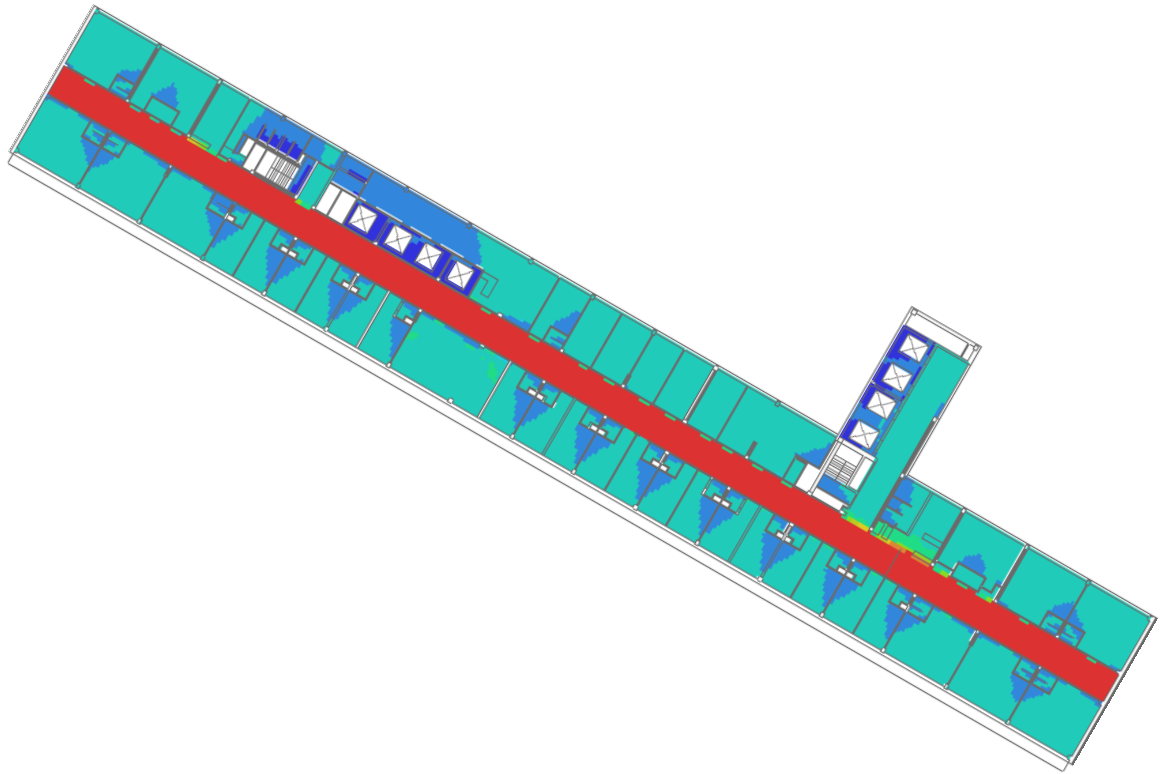
control over the interface between different user groups and encourage communication. However, the Huashan Hospital had higher axial mean connectivity and higher axial mean global integration than the NYU Bellevue Medical Center. Moreover, it had less number of axial lines per space than the NYU Bellevue Medical Center. This shows that, in the Chinese case, people need to make less turns to reach other spaces both at the local and global scale. As Rashid and Zimring (2003) have pointed out, for a given number of spaces in a layout, the lower the number of axial lines the higher the potential for interaction. Hence the layout of the Huashan Hospital has a better potential to encourage movement, informal encounter and communication.



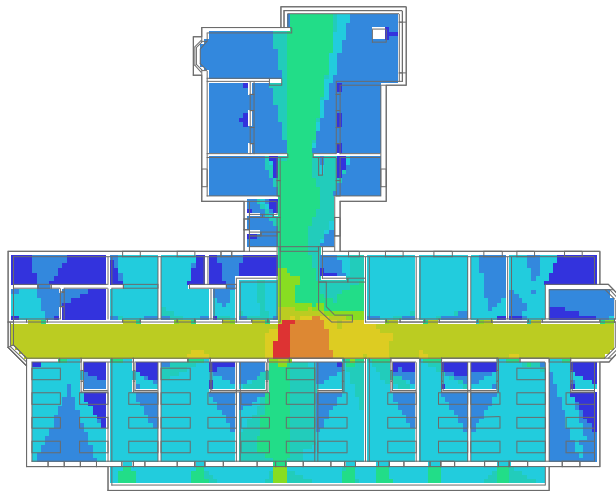
**Figure 6.9: Diagram of zones based on different spatial categories in NYU Bellevue Medical Center**



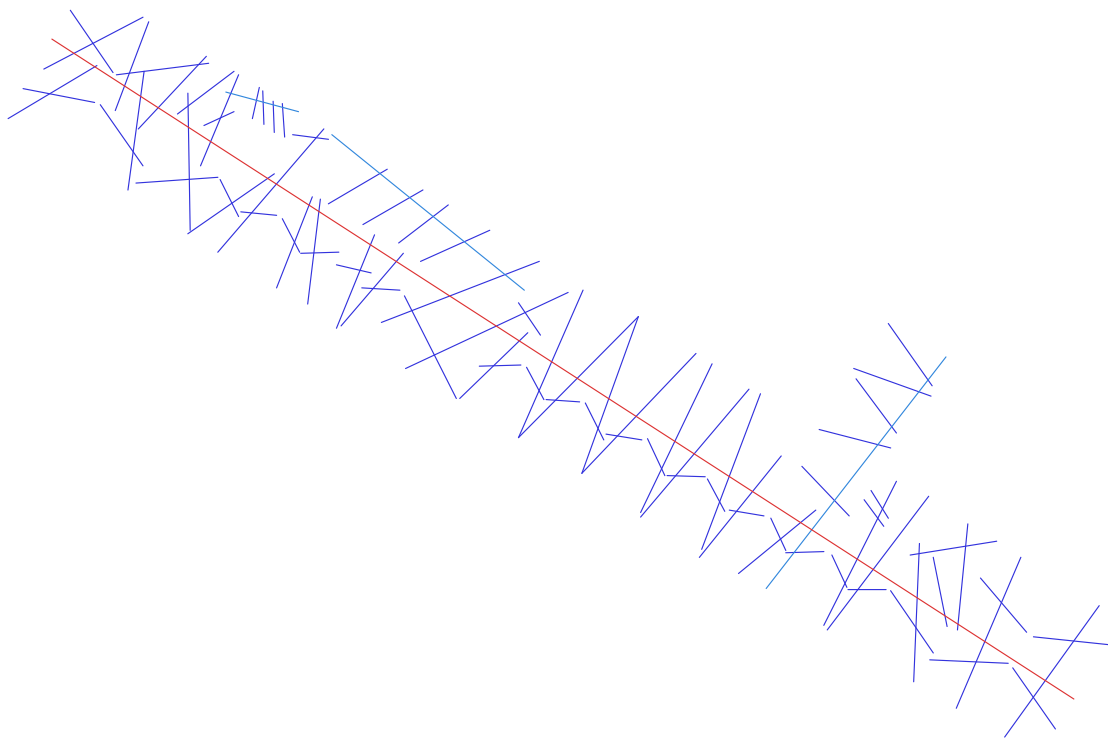
**Figure 6.10: Diagram of zones based on different spatial categories in Shanghai Huashan Hospital No.2 Building**



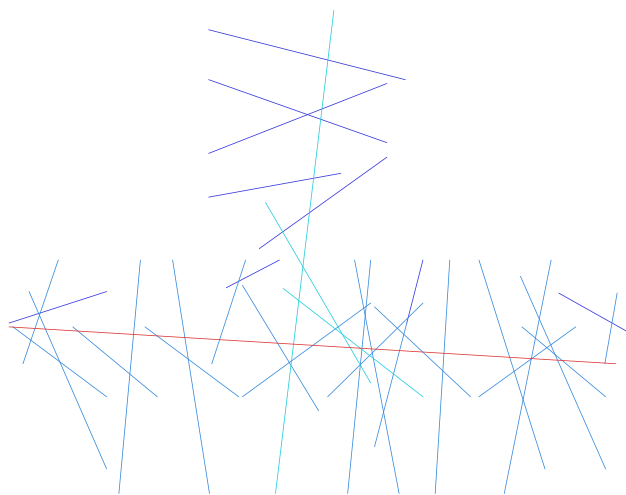
**Figure 6.11: VGA analysis on NYU Bellevue Medical Center**



**Figure 6.12: VGA analysis on Shanghai Huashan Hospital No.2 Building**



**Figure 6.13: Axial map analysis on NYU Bellevue Medical Center**



**Figure 6.14: Axial map analysis on Shanghai Huashan Hospital No.2 Building**

### **6.3.2 Comparison of the U.S. and Chinese cases with the Racetrack Layout**

In this section, the cases we compared including the two examples with the racetrack layout, the U.S. case with the distributed layout, and the Chinese case with the mutated layout. As aforementioned, the distributed layout is a unique typology in the U.S. and the mutated racetrack is a unique typology in China. The U.S. example we selected here, the Dublin Methodist Hospital, was based on a compact racetrack circulation with distributed nurse station. The Chinese example of mutated racetrack was also an adaptation of the typical racetrack layout. The similarity in the circulation theme allowed us to cross compare these four cases together.

#### **6.3.2.1 Space Economy Metrics**

In terms of the corridor length per room, both the Chinese cases had longer distance than the U.S. cases. The Chinese case for the mutated racetrack had the longest corridor length per room, while the U.S. case for the racetrack had the shortest distance. The reason might be that in the case of the mutated racetrack, i.e. the Ruijin Hospital No.9 Building, a large amount of corridor was used as the circulation for the backstage staff area, which increased the total corridor length.

The Chinese cases had much smaller area per bed when compared to the U.S. cases. However, they shared similar ratio of circulation area, which could be attributed to their similarity in the racetrack circulation theme. The distributed layout, i.e. the Dublin Methodist Hospital was the most economical layout regarding the composition of functional zones (Figure 6.15, Figure 6.16, Figure 6.17, and Figure 6.18). It had the largest ratio for patient zone and the smallest ratio for staff zone, thanks to the spatial strategy of dividing staff zone into smaller components, using alcoves outside each patient room, and setting up perching stations around columns.

#### 6.3.2.2 Staff Efficiency Measures

The distributed layout was also the most efficient design with respect to nurses' walking distance. It had the shortest average distance from nurse stations to patient rooms/patient beds, and the shortest distance from nurse stations to the furthest patient room. Both Chinese cases had longer average distance from nurse station to patient rooms and longer distance from nurse station to the furthest patient rooms. For instance, in the Shanghai Ruijin Hospital No.9 Building, the distance between the nurse station and the furthest patient room was 100 ft. It shows that in the Chinese cases, some patient rooms are quite remote from the nurse station and might had less attention from nurses. The unevenly distributed location of patient rooms regarding nurse station also makes the surveillance during night shift less efficient. Thanks to the multiple bed arrangement in each patient room, there is not a huge difference between Chinese and the U.S. cases regarding the average distance from the nurse station to patient beds. However, once the requirements for privacy and patient safety increase, the efficiency of current racetrack design in China will reduce greatly.

#### 6.3.2.3 Spatial Analysis

##### *Visual Graph Analysis*

The colored visual graph demonstrated different patterns of inter-visibility in these four layouts, even though they shared similar double corridor circulation theme (Figure 6.19, Figure 6.20, Figure 6.21, and Figure 6.22). The Shanghai No.1 People's Hospital had the largest mean connectivity and integration values, and the highest correlation between the connectivity and integration values. That shows the layout of the Shanghai No.1 People's Hospital is visually well connected both at the local and global level. The rich interconnectedness of the layout may lead to a high potential of unplanned encounter and interaction. On the other hand, the other Chinese case, the Shanghai Ruijin

Hospital No.9 Building, had the smallest mean connectivity. The consequence is that the layout has a strong sense of territoriality, as the sense of boundary increases with a decrease in the degree of visibility at the local level. The St. Joseph Hospital had the lowest mean integration value and lowest correlation between the connectivity and integration value. Yet it had quite high mean connectivity. It shows that the St. Joseph Hospital is visually well connected at the local level yet poorly connected at the global level. And that the layout is not intelligible to visitors since there is a weak correlation between the interface at the local and global level. The result is not surprising, as the St. Joseph Hospital has six sub-stations each overlooking certain number of patient rooms. Thus functionally the layout works as a combination of several sub-units. The high connectivity allows for a better control over each sub-unit. However the long curved corridor and the staff support zone located at the center of the layout diminishes the visual connections at the global level.

We also observed dissimilarities in the rank orders of the mean integration values of different space categories in these four layouts. In all cases, the circulation area had the highest integration value, yet the staff zone and the patient zone were placed differently in terms of the inter-visibility. In the Shanghai Ruijin Hospital No. 9 Building, staffs occupied less integrated area than patients. On the contrary, in the other three cases, patients were located in less integrated area than staffs. The dissimilarity in rank orders implies different spatial strategies for privacy and status. In the case of the Ruijin Hospital, the focus was on demonstrating status by locating staff in a less visually connected space. These staff areas were visually segregated from the patient zone, in order to provide a backstage area that could maintain the privacy for staff and avoid them losing “face” in front of patients. In addition, the status and high power distance was demonstrated in the very segregated location of the unit director’s office. By contrast, in

the other three cases where patients were located in less visually integrated area, the focus was on providing privacy to patients.

The colored visual graphs also revealed differences of the placement of nurse station(s). There was no traditional central nurse station in the case of the Dublin Methodist Hospital. The nurse stations were replaced by decentralized informal “perching” areas around each column and distributed multipurpose alcoves outside each patient room. The perching stations were located right next to integration cores. We expect higher potential of inter-group interaction in those perching stations due to the high inter-visibility. Similarly, the nurse stations in Shanghai No.1 People’s Hospital and Shanghai Ruijin Hospital were very close to the integration core, which might lead to strong visual control and high possibilities of encounter and interaction. On the contrary, the nurse stations in the St. Joseph Hospital had the lowest integrated value among these four cases. It means that nurses who work in those stations are less likely to have a good overall understanding of the whole unit and may feel isolated from the rest of the clinical team.

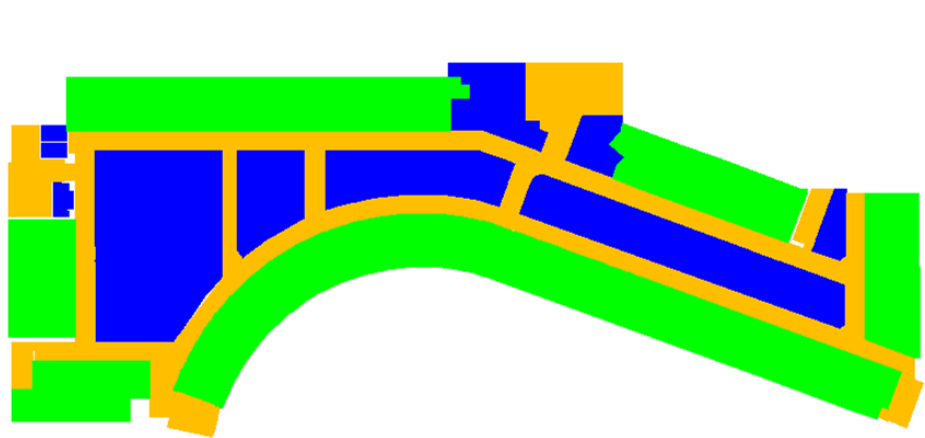
Finally, a close observation on the two Chinese cases with double corridor layout led us to some interesting findings regarding the hierarchy within the circulation system. In the Shanghai No.1 Hospital, the two corridors in the racetrack theme had very similar integration value. However, in the Shanghai Ruijin Hospital, the two corridors demonstrated very different spatial hierarchy: one is highly integrated while the other is much less visually connected to the rest of configuration. This is because, functionally, one corridor served as the main corridor that linked all patient rooms to the staff zone, and the other corridor with low integration value was used as the internal corridor within the staff zone.

#### *Axial Map Analysis*

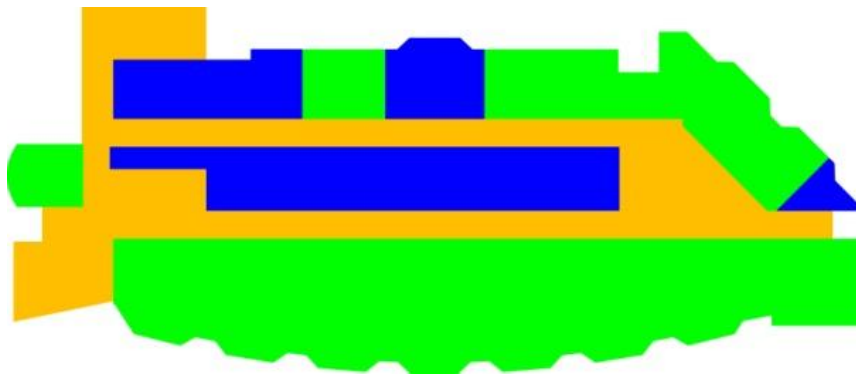


The axial map analysis also displayed dissimilar degree of physical accessibility within these layouts (Figure 6.23, Figure 6.24, Figure 6.25, and Figure 6.26). Similar to the results of the visual graph analysis, the Shanghai No.1 People's Hospital had the highest mean integration and mean connectivity values. It also had the fewest number of axial lines per space. Moreover, it had a strong correlation between connectivity and global integration. These findings show that the configuration of the Shanghai No.1 People's Hospital supports inter-group encounter and serendipitous communication. The St. Joseph Hospital had the largest number of axial lines per space and weakest correlation between connectivity and global integration. Therefore it had less intelligible local and global order and it diminished the chances for informal interaction.

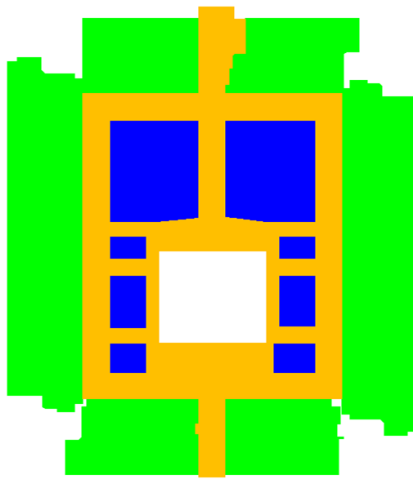
These four layouts were also very different with respect to the configuration of the axial maps. The Dublin Methodist Hospital had the most egalitarian axial structure among these four cases. All patient rooms and most staff work area were no more than one-step-away from the wheel-like circulation core. There was no clear sense of territory and distinct spatial hierarchy. Some very integrated lines ran through spaces of different types, such as the patient zone, the staff zone and the circulation area. These were achieved by taking away the enclosure of traditional nurse station. The Shanghai Ruijin Hospital No. 9 Building had the strongest sense of territoriality and spatial hierarchy. The staff zone had a very highly inter-connected axial structure that was cut across by very few axial lines and weakly connected to the rest of the global structure. Therefore, the layout provided a distinct boundary between caregivers and patients. By contrast, the Shanghai No.1 People's Hospital had less clear demarcation of the boundaries among different user groups. The reason could be attributed to the large open nurse station located at the center of the layout that encouraged movement and encounter both within and across groups. Except one area, the St. Joseph Hospital did not display well-defined territory.



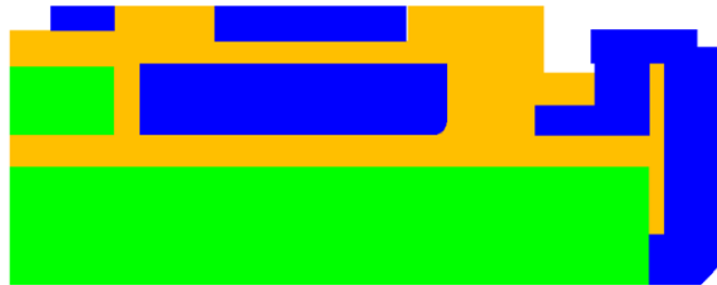
**Figure 6.15: Diagram of zones based on different spatial categories in St. Joseph Hospital**



**Figure 6.16: Diagram of zones based on different spatial categories in Shanghai No.1 People's Hospital**



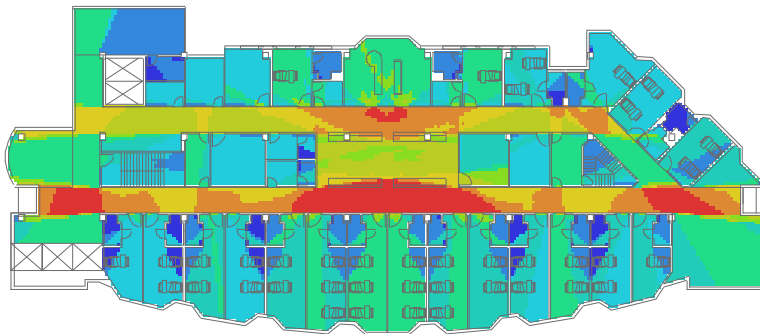
**Figure 6.17: Diagram of zones based on different spatial categories in Dublin Methodist Hospital**



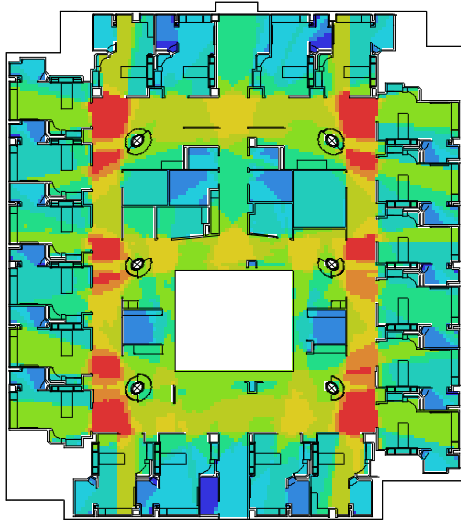
**Figure 6.18: Diagram of zones based on different spatial categories in Shanghai Ruijin Hospital No.9 Building**



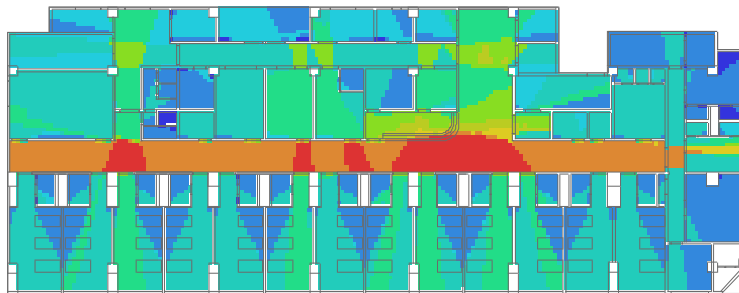
**Figure 6.19: VGA on St. Joseph Hospital**



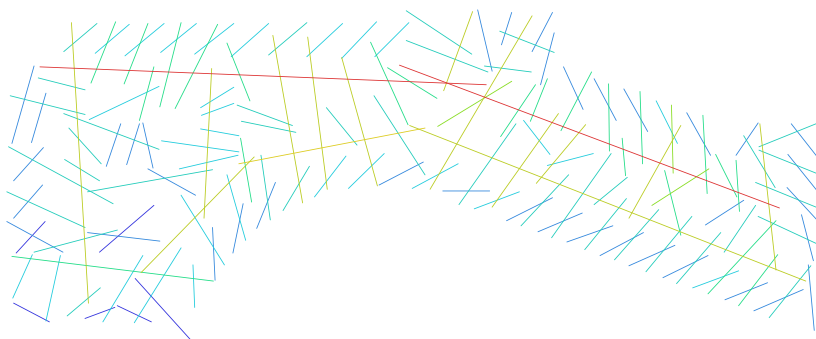
**Figure 6.20: VGA on Shanghai First People's Hospital**



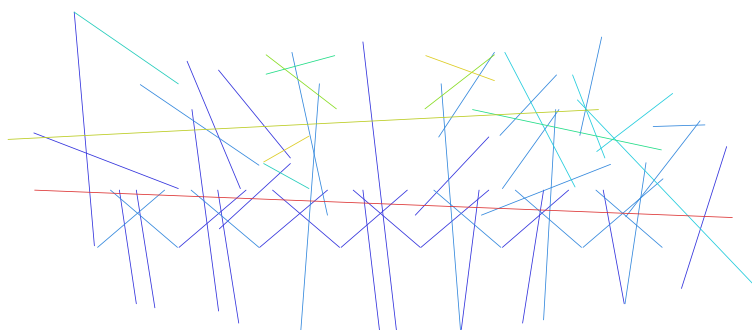
**Figure 6.21: VGA on Dublin Methodist Hospital**



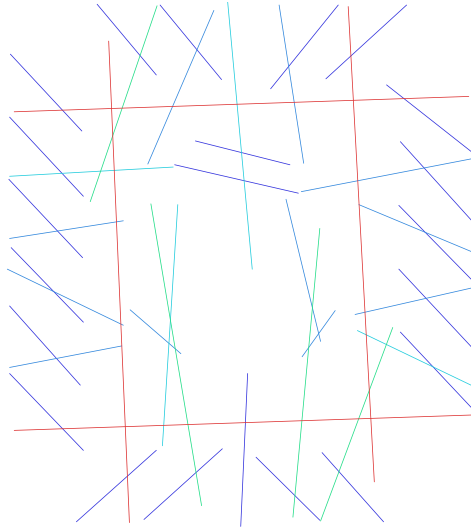
**Figure 6.22: VGA on Shanghai Ruijin Hospital No. 9 Building**



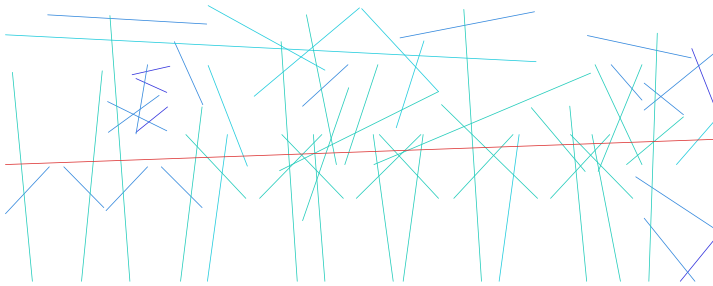
**Figure 6.23: Axial map analysis on St. Joseph Hospital**



**Figure 6.24: Axial map analysis on Shanghai No.1 People's Hospital**



**Figure 6.25: Axial map analysis on Dublin Methodist Hospital**



**Figure 6.26: Axial map analysis on Ruijin Hospital No.9 Building**

### **6.3.3 Comparison of the U.S. and Chinese cases with the Radial Layout**

#### **6.3.3.1 Space Economy Measures**

The U.S. case of the radial layout had much smaller corridor length per patient room and per patient bed than the Chinese case. The difference could be contributed to the dissimilar ways of locating the staff zone. Although in both layouts, the nurse station was placed at the center of the radial or hexagon-shape unit to maximize surveillance on patients, the rest of staff support zone was placed differently. In the U.S. case, i.e. the Kaiser Foundation Hospital, the staff support zone was located at the joints of two radial units and shared between these two units. However, in the Chinese case, the Chongqin Southwest Hospital, the staff support area was designed as a separate zone that was attached to the southwest corner of the hexagon-shape unit. The remote location of the staff support zone comparing to the patient zone greatly increased the corridor length per patient room.

The Kaiser Foundation Hospital was also more economical than the Chongqin Southwest Hospital with respect to the space utilization. The former had smaller area per bed and larger proportion of patient zone than the latter. We also noticed that the staff zone in the Kaiser Foundation Hospital occupied only 8% of the total area, while the one in the Chongqin Southwest Hospital took 31% of the total area (Figure 6.27, Figure 6.28). The difference was again due to the placement of the staff zone previously mentioned. What was common in these two cases was that both circulation areas took a large amount of space. The reason might be because both cases had two layers of corridors, with the internal one for staff and the external one for family and visitors. However, the double-layered corridor arrangement was not typical for all radial layouts. We speculate that regular radial layouts with just the internal corridor will have smaller ratio of circulation area.



#### 6.3.3.2 Staff Efficiency Measures

Both cases seemed to be very efficient in terms of the distance from nurse station to patient rooms/beds. In addition, there was very small difference among the distances from the nurse station to various patient rooms. That shows that most patient rooms in these two cases may get equal amount of attention from nurses.

#### 6.3.3.3 Spatial Analysis

##### *Visual Graph Analysis*

These two radial layouts shared very similar patterns of inter-visibility both at the local and global levels (Figure 6.29, Figure 6.30). The mean connectivity, mean integration and the correlation between the connectivity and integration values were comparable in these two layouts. In addition, in both cases, the nurse station was located at a highly integrated area for the purpose of visual surveillance. However, when we further compared the integration values of various functional zones, we found different rank orders of spaces. In the case of the Kaiser Foundation Hospital, the staff zone had the highest mean integration value, followed by the circulation area, and the patient zone had the least mean integration value. By contrast, in the case of the Chongqin Southwest Hospital, the circulation area had the highest mean integration value, followed by the staff zone, and the patient zone had the least mean integration value. The low integration value of the staff zone in the Chinese case was due to its remote location comparing to the rest of the configuration.

##### *Axial Map Analysis*

At the first glance, the results of the axial map analysis showed great similarities between these two layouts (Figure 6.31, Figure 6.32). They had comparable values of number of axial lines per space, mean connectivity, mean global integration, and the

correlation between connectivity and global integration. However a careful examination on the structure of the colored axial map revealed some intriguing differences. No spatial territory was evident in the colored axial map of the Kaiser Foundation Hospital. The integration core was located at the center of the two radial units. The axial structure followed the geometric order of the layout. On the other hand, there was a strong sense of spatial territory in the configuration of the colored axial map of the Chongqin Southwest Hospital. There was a distinct demarcation of the boundary between the patient zone and the staff zone. In addition, the axial structure did not follow the geometric order of the configuration, as its integration core was lumped on one side of the layout that contained the staff zone. Consequently, in the Chongqin Southwest Hospital, there was stronger control over the interface between patients and caregivers. Meanwhile, the highly integrated corridors in its staff zone provided a good potential for in-group interaction among caregivers from different disciplines.

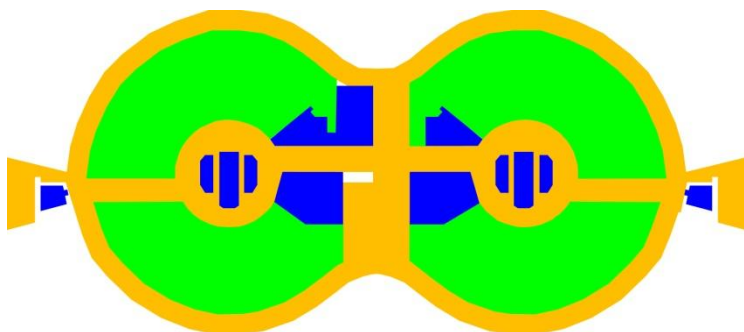


Figure 6.27: Diagram of zones based on different spatial categories in Kaiser Foundation Hospital

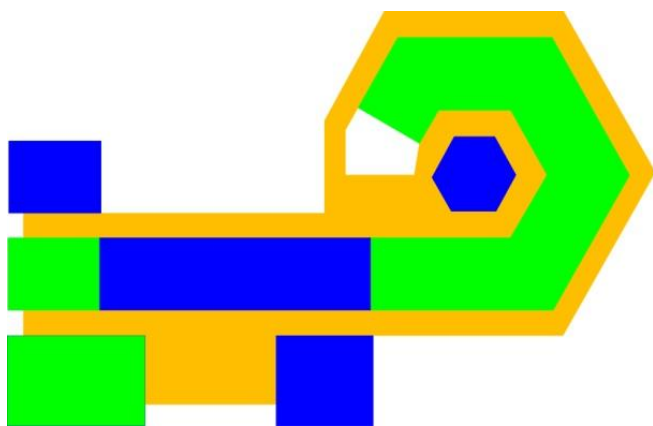
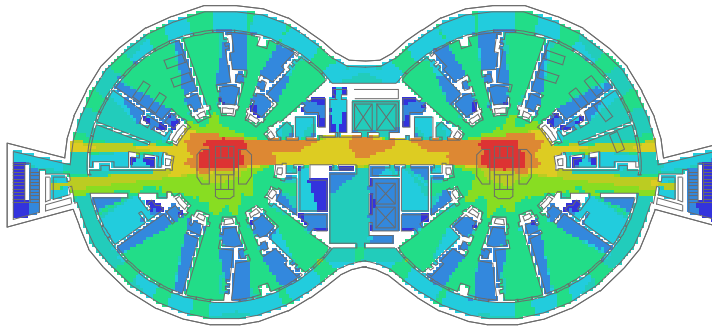
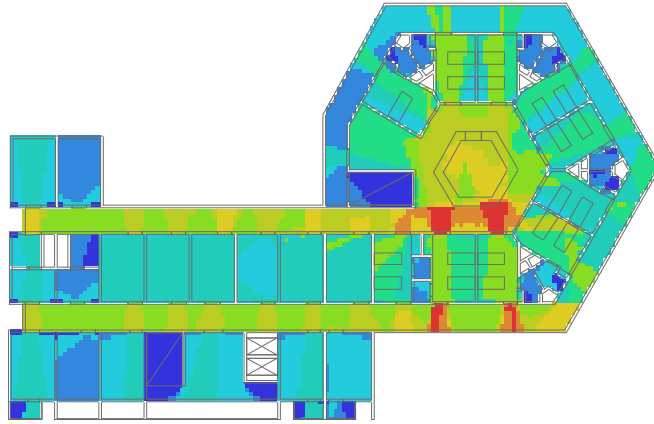


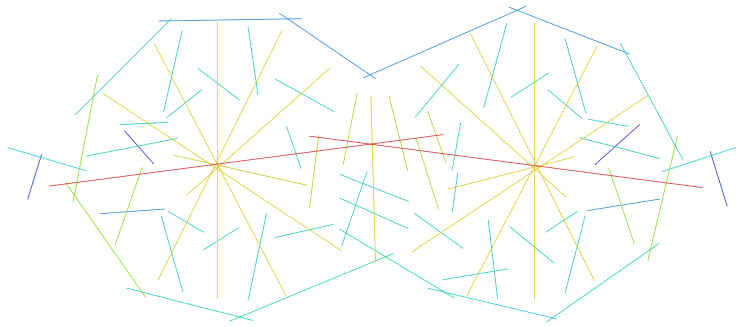
Figure 6.28: Diagram of zones based on different spatial categories in Chongqing Southwest Hospital



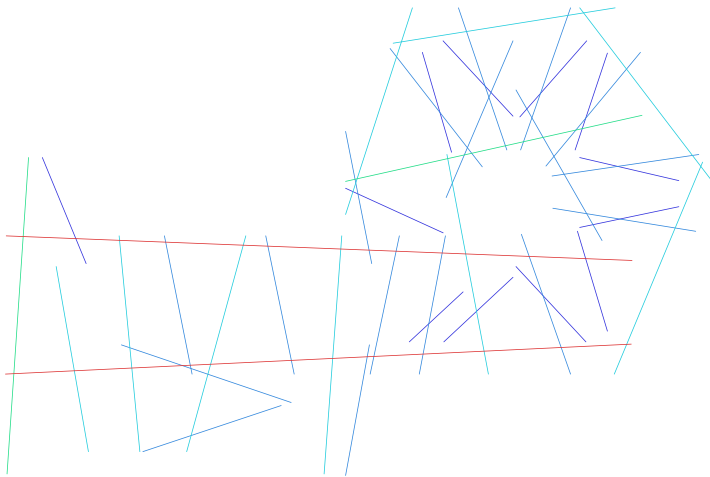
**Figure 6.29: VGA on Kaiser Foundation Hospital**



**Figure 6.30: VGA on Chongqin Southwest Hospital**



**Figure 6.31: Axial map analysis on Kaiser Foundation Hospital**



**Figure 6.32: Axial map analysis on Chongqin Southwest Hospital**

### **6.3.4 Comparison of the U.S. and Chinese cases with the Triangular Layout**

#### **6.3.4.1 Space Economy Measures**

Both the Emory Hospital 5E unit and the Sichuan Third Hospital were based on a triangular-shape circulation system. They were very similar with respect to the economy measures. These two triangular layouts shared similar corridor length per patient room. They also had similar allocation of different functional zones (Figure 6.33, Figure 6.34). However, due to the multiple-bed arrangement in the Sichuan Third Hospital, it had much smaller corridor length per patient bed and smaller area per bed than the Emory Hospital 5E unit.

#### **6.3.4.2 Staff Efficiency Measures**

The dissimilarities between these two layouts were more evident when we compared the efficiency measures. The U.S. case had much smaller average distance from the nurse station to patient rooms and smaller distance from the station to the furthest patient room than the Chinese case. The difference was due to dissimilar spatial strategies in the arrangement of patient rooms and nurse station. In the U.S. case, patients occupy three sides of the triangular unit, while nursing staff occupy the center of the unit for the benefits of shortening walking distance and maximizing visual surveillance. By contrast, in the Chinese example, patient rooms were arranged along two south-facing sides of the triangular-shape unit, with the nurse station located at the crossing point of these two sides, overlooking the lobby of vertical traffic instead of patient rooms. This layout sacrificed not only the efficiency, but also the ease of surveillance, just for the sake of having maximum southern sunlight for most patient rooms. Though thanks to the multiple-bed arrangement, the Chinese case ended up having similar average distance from nurse station to patient beds with the U.S. case.

#### 6.3.4.3 Spatial Analysis

##### *Visual Graph Analysis*

The visual graph analysis uncovered differences between these two layouts with respect to inter-visibility of the configuration (Figure 6.35, Figure 6.36). The Emory Hospital 5E had much higher connectivity and integration values than the Sichuan Third Hospital. Moreover, a larger portion of space in the Emory Hospital was located at a highly integrated area, whereas only small spots in the Sichuan Third Hospital had high integration values. The consequence is that the Emory Hospital 5E provides a better field of potential encounters and interactions. In addition, the nurse stations in the U.S. case had much higher integration values than those in the Chinese case. In other words, the nurse stations in the Emory Hospital 5E have richer visual connections to the rest of the configuration, thus better awareness of the whole unit.

Despite the above differences, both layouts had strong correlations between the connectivity and integration values. It shows that both layouts have intelligible local and global structure. These two layouts also had the same rank order of different categories of spaces. In both cases, the circulation had the highest integration value, followed by the staff zone, and the patient zone had the lowest integration value.

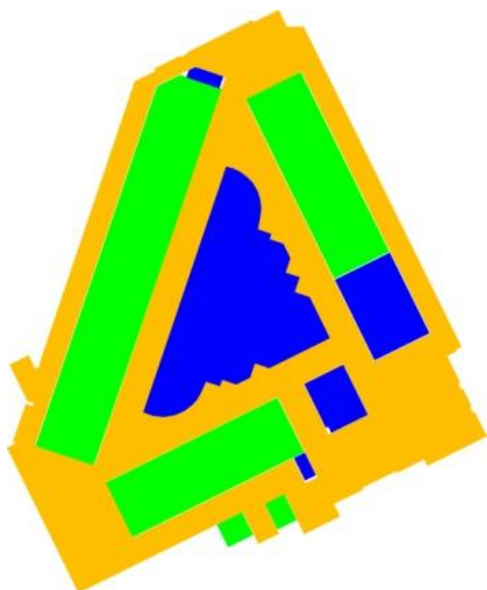
##### *Axial Map Analysis*

The structures of the colored axial maps of these two layouts resembled more similarities than differences (Figure 6.37, Figure 6.38). No clear sense of territoriality could be observed from the configurations of both axial maps. The result was surprising since there seemed to be an obvious distinction between the patient zone and the staff zone in the case of the Sichuan Third Hospital. However the boundary of these two zones was diminished by the very integrated corridor that linked the staff zone with the rest of the unit.

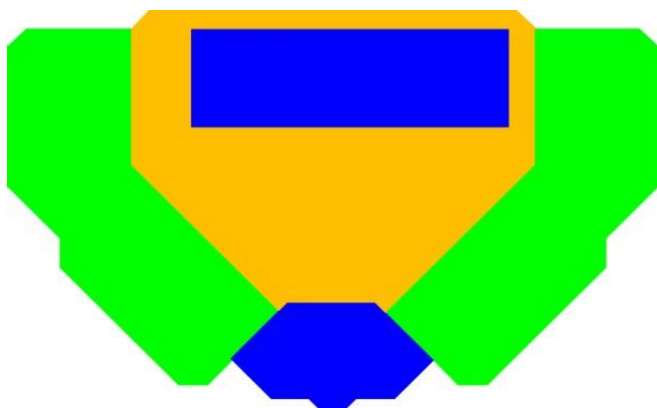
Both layouts had strong correlations between the connectivity and global integration values, which implied the existence of an intelligible local and global structure with respect to movement and accessibility. It also shows that the patterns of local system resemble the patterns of global system, which leads to lower sense of territoriality and more opportunities for interactions to happen outside the immediate group.

However, for the accessibility calculated by the axial map analysis, the Emory Hospital 5E had higher mean connectivity, mean global integration values than the Sichuan Third Hospital. It means that the Emory Hospital 5E has a more weakly programmed space, thus has a higher potential for serendipitous communications across different user groups.

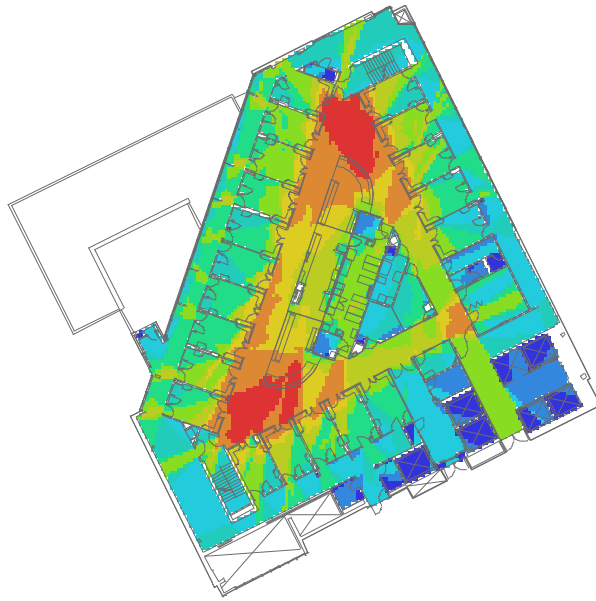




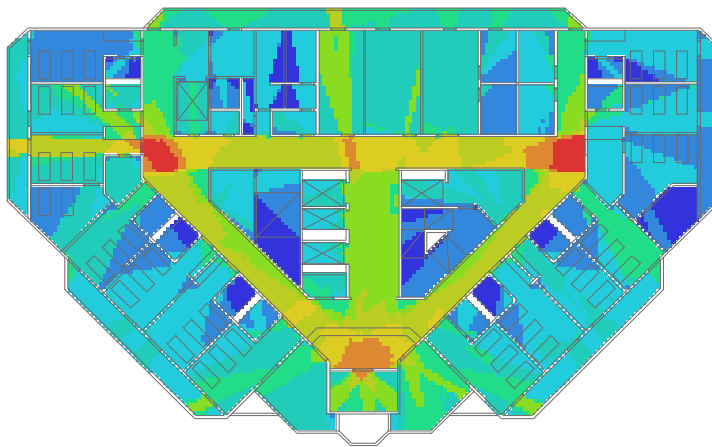
**Figure 6.33: Diagram of zones based on different spatial categories in Emory Hospital 5E unit**



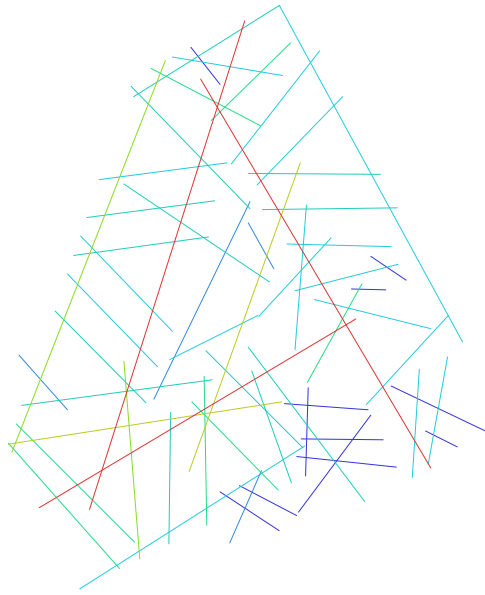
**Figure 6.34: Diagram of zones based on different spatial categories in Sichuan Third Hospital**



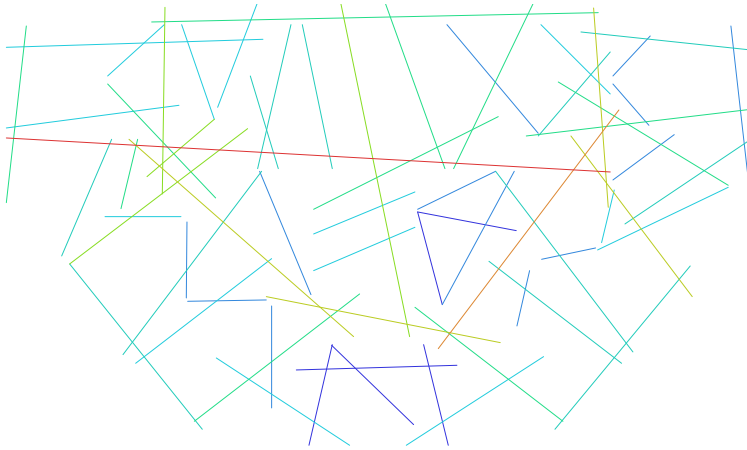
**Figure 6.35: VGA on Emory Hospital 5E unit**



**Figure 6.36: VGA on Sichuan Third Hospital**



**Figure 6.37: Axial map analysis on Emory Hospital 5E unit**



**Figure 6.38: Axial map analysis on Sichuan Third Hospital**

### **6.3.5 Comparison of the U.S. and Chinese cases with the Cluster Layout**

#### **6.3.5.1 Space Economy Measures**

Both the Chengdu TCM University Affiliated Hospital and the Hasbro Children's Hospital were based on the cluster/pod layout to shorten nurses' walking distance and increase work efficiency. The Chinese case was composed of three honeycomb-shape clusters, among which two clusters on the south were the patient zones and the third on the north was the staff zone. The Hasbro Children's Hospital had five pods, including three pods for patient rooms, one pod for vertical circulation, and one large central pod for staff support area. The Chinese case of the cluster layout was much more economical than its U.S. counterpart, with much smaller corridor length per patient room, corridor length per patient bed, and area per bed. The large corridor length in the Hasbro Children's Hospital was due to the loop corridor that wraps around the central support pod and a long diagonal corridor that cut through the central support pod to convey visitors from the lobby to a reception desk.

When we compared the ratios of different functional zones, the Hasbro Children's Hospital had a larger proportion of staff area than the Chengdu TCM Hospital (Figure 6.39, Figure 6.40). Moreover, the Chinese case had larger ratio of patient zone than the U.S. case. Hence, the Chengdu TCM Hospital is considered more economical as larger portion of the construction area is dedicated to patients when compared to the Hasbro Children's Hospital.

#### **6.3.5.2 Staff Efficiency Measures**

The Chinese case was more efficient than the U.S. case regarding the nurses' walking distance. It had shorter average distance from nurse station to patient room, average distance from nurse station to patient bed. In addition, the variance of the

distance from nurse station to each patient room was smaller in the Chinese case than the U.S. case.

#### 6.3.5.3 Spatial Analysis

##### *Visual Graph Analysis*

The visual graph analysis of these two layouts presented more similarities than differences (Figure 6.41, Figure 6.42). Both layouts had comparable integration values and correlation between connectivity and integration values. Moreover, these two layouts had similar rank orders for different categories of space, with the circulation area having the highest integration value, followed by the staff zone, and the patient zone having the lowest integration value. In both cases, a registration desk was placed at the integration core to provide maximum control over the traffic.

The major difference of these two layouts was at the local level. The Chengdu TCM Hospital had lower mean connectivity value than the Hasbro Children's Hospital had. The implication here is that each node in the Chinese case has limited direct visibility towards other locations, thus leads to stronger sense of boundary and territoriality.

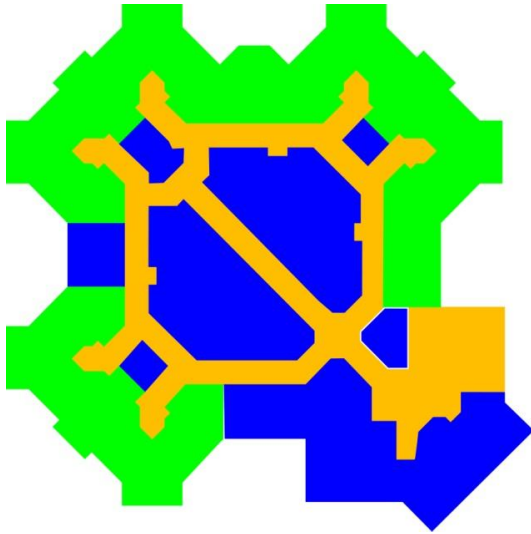
##### *Axial Map Analysis*

The axial map analysis also demonstrated similarities between these two layouts (Figure 6.43, Figure 6.44). Both cases had comparatively low number of axial lines per space, which suggested few turns were needed to reach other spaces in the unit. It could be attributed to the cluster/pod design that allows an easy access at the local level. They had comparable mean global integration. In addition, the correlation between the local and global interface was weak in both the Chinese case and the U.S. case. This shows that both cluster layouts are not intelligible to users, in other words, it is difficult for a

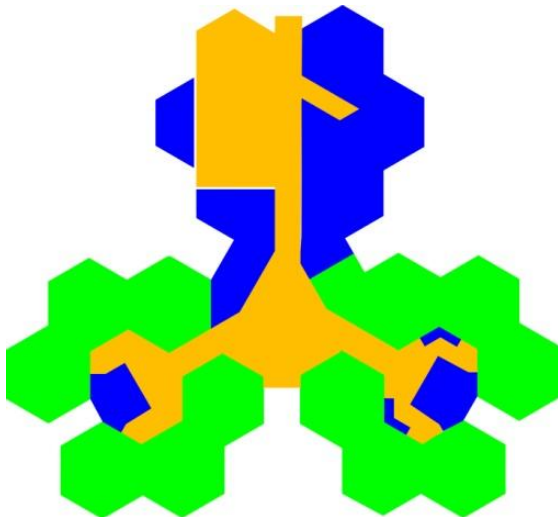
situated user to understand the overall layouts from the local structure, and find his way around the cluster units.

However, the Chengdu TCM Hospital had higher mean connectivity than the Hasbro Children's Hospital. Therefore the layout of the former was more accessible both at the local level than the latter. The close connectedness of local areas helps to form the sense of community and territoriality in the Chinese case.

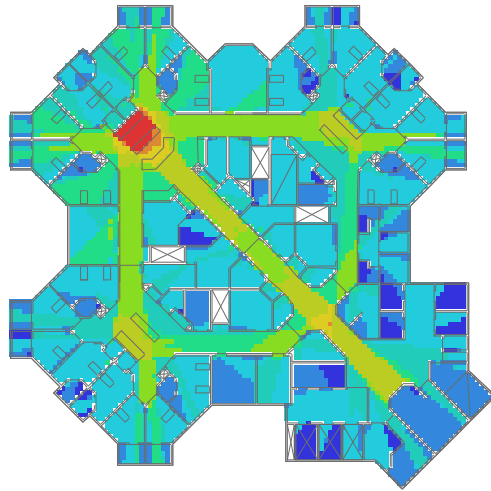
From the colored axial map, we also observed a clear sense of territoriality in the Chengdu TCM Hospital. Few highly integrated axial lines linked various territories formed by the clusters. On the contrary, in the Hasbro Children's Hospital, the strong sense of territoriality was diminished by several short axial lines that ran through various pods.



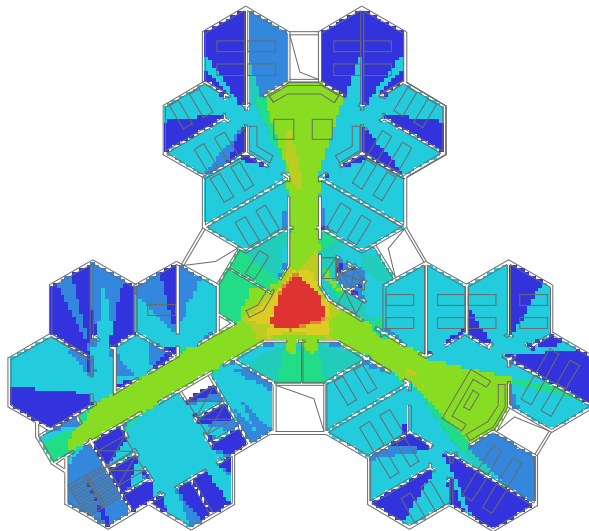
**Figure 6.39: Diagram of zones based on different spatial categories in Hasbro Children's Hospital**



**Figure 6.40: Diagram of zones based on different spatial categories in Chengdu TCM Hospital**

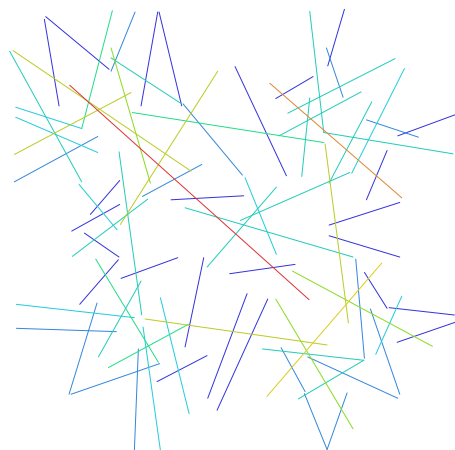


**Figure 6.41: VGA on Hasbro Children's Hospital**

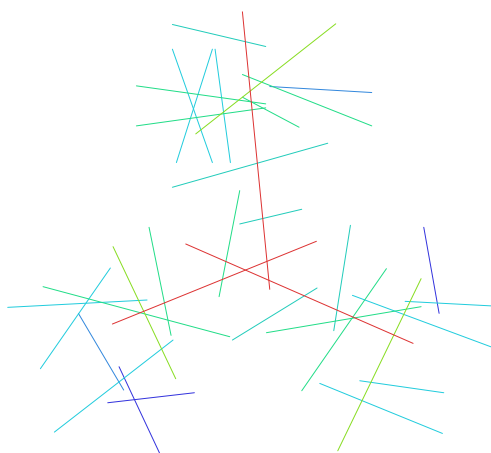


**Figure 6.42: VGA on Chengdu TCM Hospital**





**Figure 6.43: Axial map analysis on Hasbro Children's Hospital**



**Figure 6.44: Axial map analysis on Chengdu TCM Hospital**

#### 6.4 Overall Comparison of the U.S. and Chinese cases

In previous two sections, we have firstly compared different typologies with the nationality controlled, and then compared designs from the U.S. and China with the nursing unit typologies controlled. In this section, we cross compared all the U.S. and Chinese cases. The focus was to reveal any systematic national difference in applying nursing unit typologies in these two countries. Based on literature reviews on national culture and health care in China, we stated one main research proposition and extended seven sub-propositions as follows,

**Research proposition:** Chinese nursing unit designs are different from their U.S. counterparts in that they retain certain characteristics that reflect Chinese spatial behaviors. Chinese nursing unit typologies have been modified from their Western sources to accommodate to the cultural needs of the Chinese.

**Sub-Proposition 1:** Chinese nursing units are more economical in terms of space allocation than the U.S. counterparts. This may be due to the more challenging economic conditions and lower expectations for privacy in China.

**Sub- Proposition 2:** Chinese nursing units are more efficient than those in the U.S. This may be due to the designers' awareness of a low staff-to-patient ratio.

**Sub- Proposition 3:** Patient beds in Chinese nursing units have more access to southern sunlight exposure than those in the U.S. nursing units. The reason might be rooted in the widespread belief in *Fengshui* and the healing power of physical orientation and natural light.

**Sub-Proposition 4:** Chinese nursing units support face-to-face communication better than the U.S. counterparts. This may be due to China's preference for a "high-context" communication style.

**Sub-Proposition 5:** Chinese nursing units have a stronger spatial hierarchy than the U.S. nursing units. It might be due to the high power distance in Chinese culture.

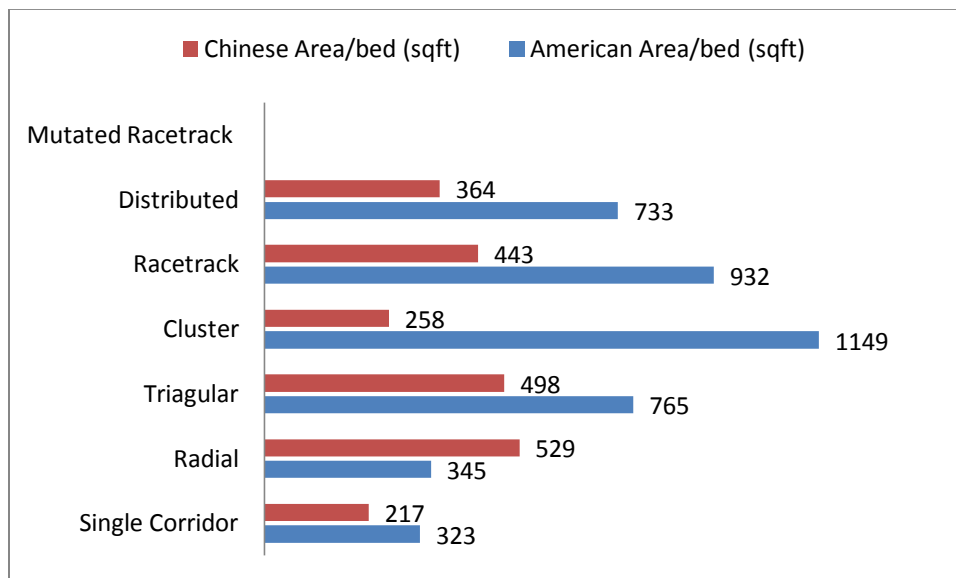
**Sub-Proposition 6:** Chinese nursing units have stronger sense of territoriality, possibly stemming from the cultural trait of collectivism and the concern for “*guanxi*” (the social network).

**Sub-Proposition 7:** Chinese nursing units have a larger proportion of “backstage” or private areas for employees. This may be due to the cultural preference for “saving face.”

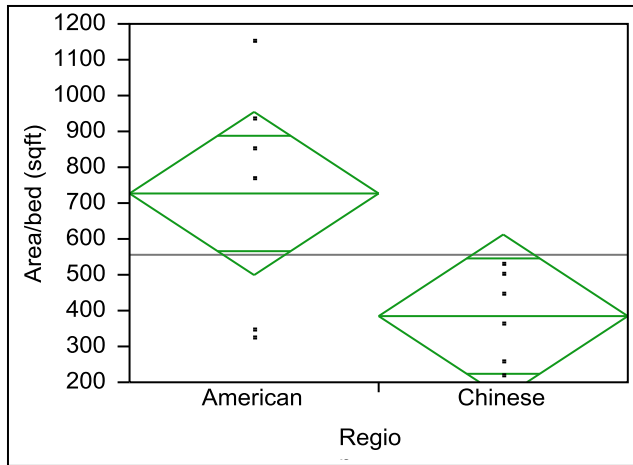
#### 6.4.1 Sub-Proposition 1: Chinese Layouts are More Economical in Space

##### Allocation

We firstly conducted a t-test on values of corridor length per room, corridor length per bed, and area per bed between Chinese and the U.S. units. There was a statistically significant difference of the area per bed between Chinese and the U.S. designs ( $p < 0.05$ ), despite the typologies used in the design (Figure 6.45, Figure 6.46). It partially supported the sub-proposition one that the Chinese nursing units are more economical than the U.S. ones. The comparison between the U.S. and Chinese units with typologies controlled also demonstrated similar result.

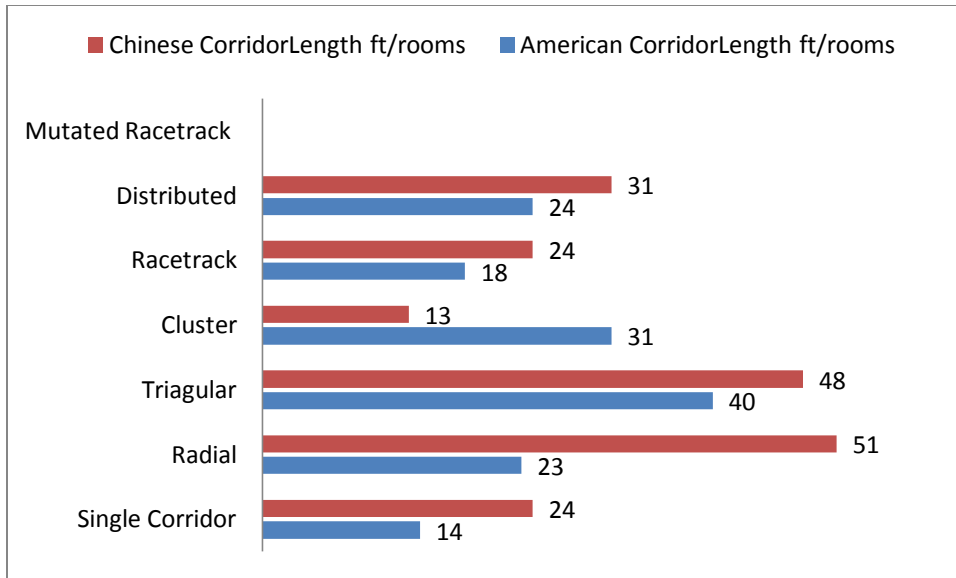


**Figure 6.45: Comparison of area per bed by country and typology. Most of the Chinese cases have smaller area per bed when compared to the U.S. cases with the same typology.**

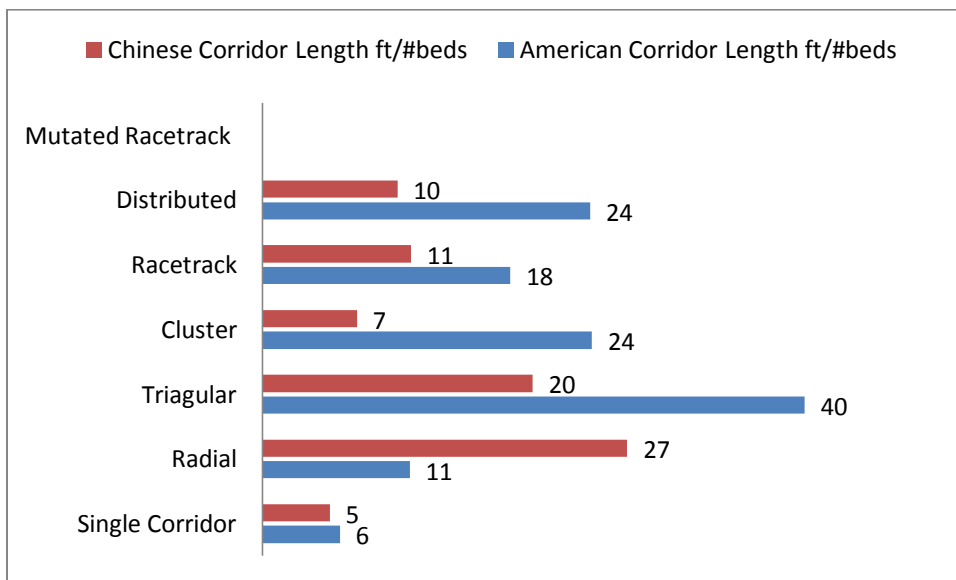


**Figure 6.46: T-test of area per bed between the U.S. and Chinese nursing units. the U.S. cases have significantly higher area per bed than Chinese cases.**

However, when we compared the corridor length between the U.S. and Chinese cases, the results were not statistically different. The difference was more evident when we compared the Chinese and the U.S. case with the same typology. For most typologies, the Chinese cases had longer corridor length per room when compared to their U.S. counterparts, except the case of the cluster layout (Figure 6.47). In terms of corridor length per bed, most of the Chinese cases had smaller values than the U.S. cases with the same typology, except the case of the radial layout (Figure 6.48). It shows that under current multiple-bed patient room theme, the Chinese nursing unit designs are more economical than U.S. ones. However, with the gradual transition from multiple-bed patient rooms to double or single patient room in China, we expect some design changes have to be done to maintain the same standard of being economical in terms of corridor length per bed.

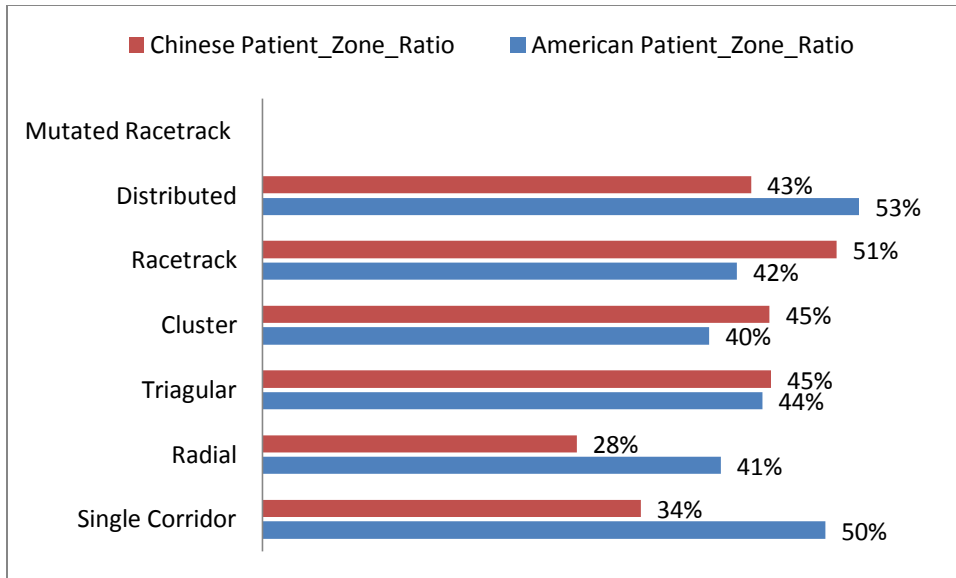


**Figure 6.47: Comparison of corridor length per patient room by country and typology. For most typologies, the Chinese cases had longer corridor length per room when compared to the U.S. counterpart.**

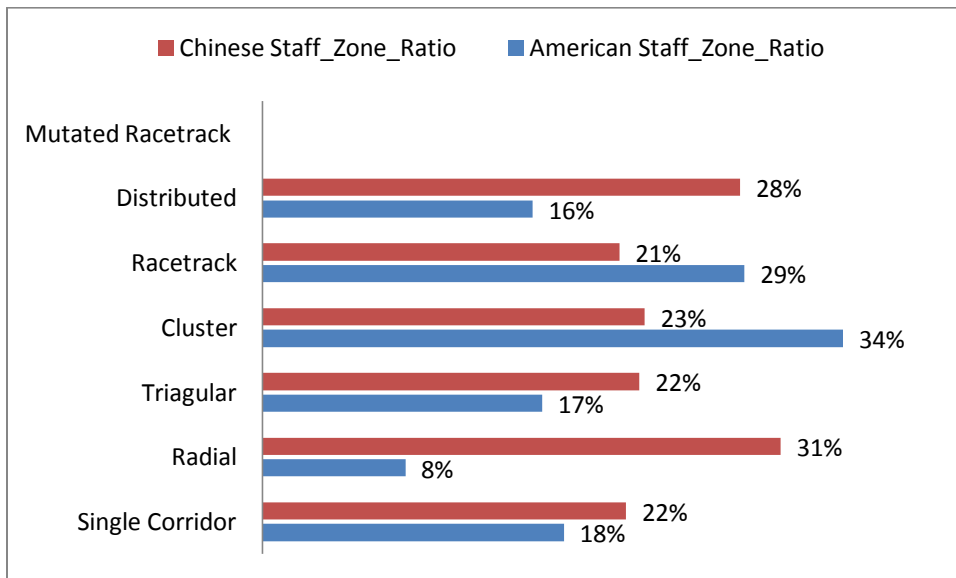


**Figure 6.48: Comparison of corridor length per patient bed by country and typology. Most of the Chinese cases had smaller values than the U.S. cases with the same typology.**

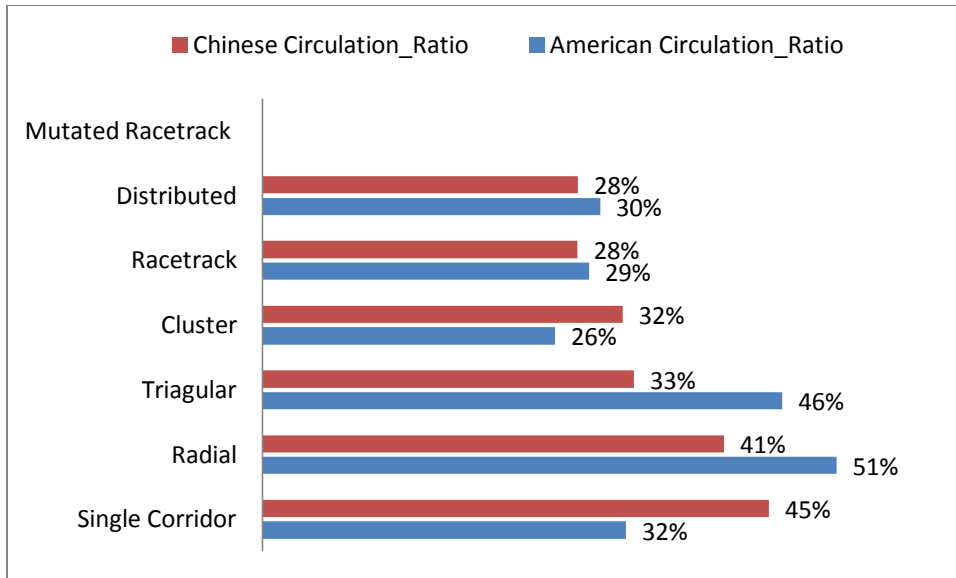
The comparison of the composition of various functional zones didn't display any consistent pattern of differences between Chinese and U.S. nursing unit designs (Figure 6.49, Figure 6.50, and Figure 6.51).



**Figure 6.49: Comparison of the ratio of patient zone by country and typology. No consistent pattern of differences between Chinese and the U.S. nursing unit designs are displayed.**



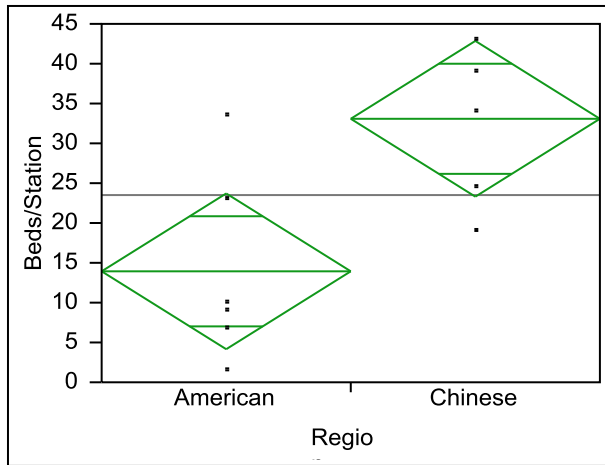
**Figure 6.50: Comparison of the ratio of staff zone by country and typology. No consistent pattern of differences between Chinese and American nursing unit designs are displayed.**



**Figure 6.51: Comparison of the ratio of circulation zone by country and typology. No consistent pattern of differences between the U.S. and Chinese nursing unit designs are displayed.**

#### **6.4.2 Chinese Nursing Units Are More Efficient**

Efficiency measures emphasize on how well the design in support of the caregivers' work. Due to the high patient-to-nurse ratio, we assume that the Chinese nursing units design has to meet higher demands on efficiency. As we have mentioned in the Chapter 2, the patient-to-nurse ratio is much higher in China than in the U.S. It is around 10-1 during day shifts and even 12-1 during night shifts in Chinese nursing units. The calculation of the number of beds per nurse station in the selected 12 cases further confirmed the high work load of Chinese nurses. The t-test demonstrated a statistically significant higher number of beds per station in the Chinese cases when compared to the U.S. cases ( $p < 0.05$ ) (Figure 6.52).

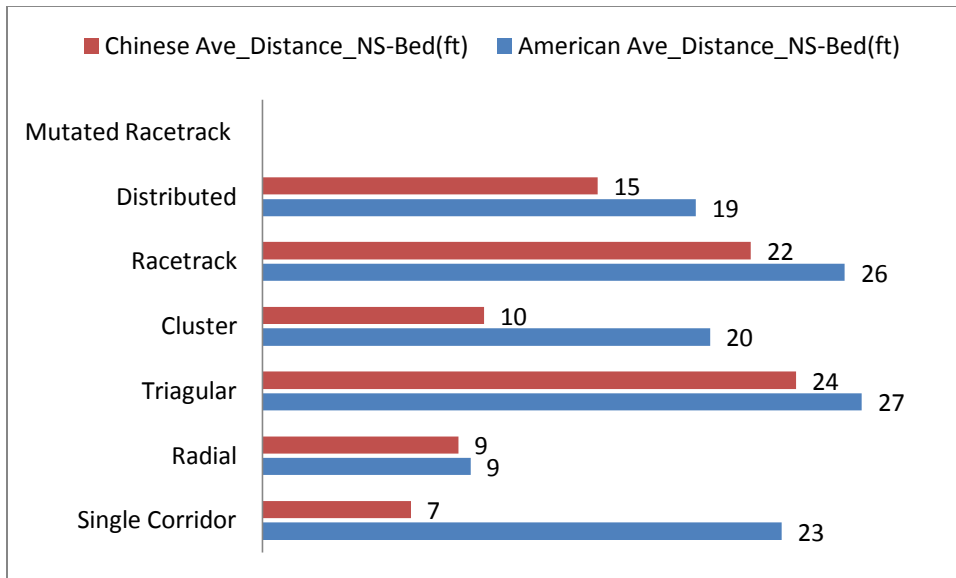


**Figure 6.52: T-test of the number of beds per nurse station between the U.S. and Chinese cases**

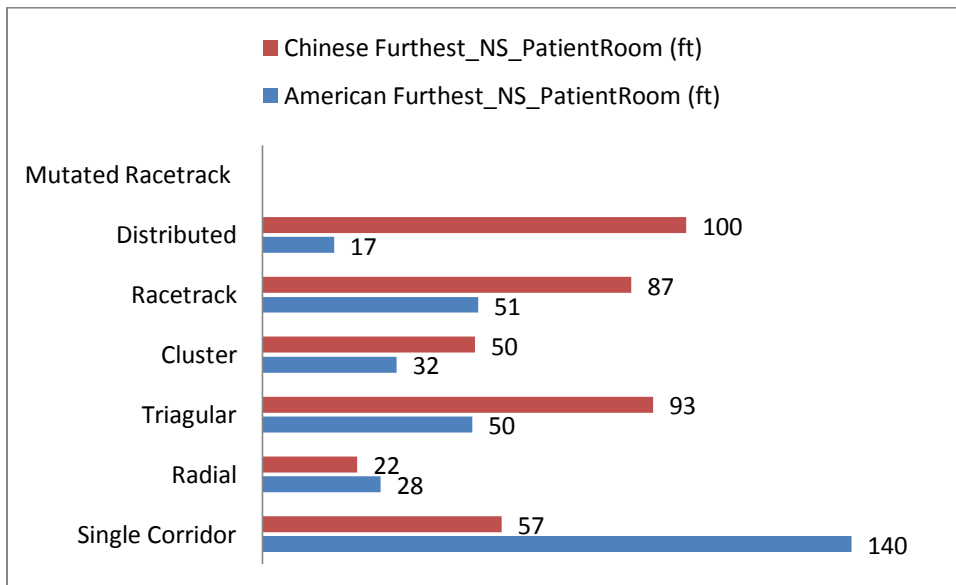
When we conducted the t-test on the U.S. and Chinese cases without considering their typologies, there was no statistically significant difference between the average distance between nurse stations and patient beds. However when we considered the factor of the nursing unit typologies, the data did display a trend that most Chinese nursing units had shorter walking distances from nurse stations to patient beds than their the U.S. counterparts with the same typologies (Figure 6.53). It showed that the typology played an important role in the efficiency of a layout. The result was consistent with prior studies on the relationship between floor plates and travels distances (Shpuza, 2006; Tabor, 1976; Willoughby, 1975). Based on a thorough literature review, Shpuza (2006) pointed out the strong effects of the floor plate shapes on the configuration of the circulation scheme, and in turn the travel distances. According to Tabor (1976), the floor plate shape had strong effects on the average walking distances among destinations that were not close to each other: the cross worked better for minimizing travels distances than slab or court. Similarly, when Willoughby (1975) compared the mean lengths of trips among each department across five floor plan shapes of slab, court, cross, fishbone and open-plan with 1 to 12 departments of equal size, he discovered a close relationship between circulation patterns and floor plate shapes.



The comparison on the furthest distance and average distance between nurse stations and patient rooms didn't reveal any consistent trend (Figure 6.54). Hence the sub-proposition two is partially supported that the Chinese nursing units are more efficient than the U.S. cases in terms of average distance from nurse stations to patient beds.



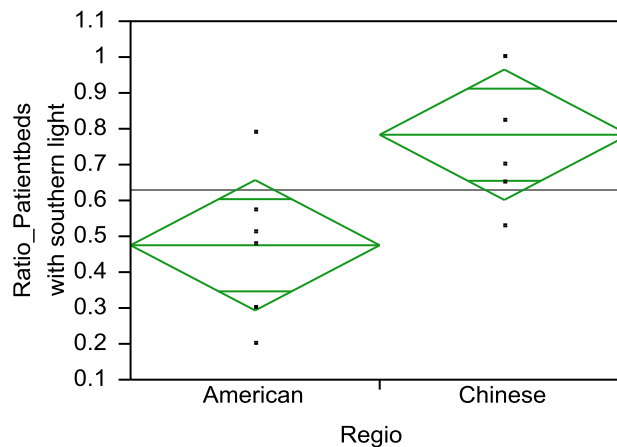
**Figure 6.53: Comparison of average distance from nurse stations to patient beds by country and typology. Most Chinese nursing units had shorter walking distances from nurse stations to patient beds than their American counterparts with the same typology.**



**Figure 6.54: Comparison of furthest distance from nurse stations to patient rooms by country and typology didn't reveal any consistent trend.**

### 6.4.3 Patient Beds In Chinese Nursing Units Have More Access To Southern Sunlight Exposure

In this study, we intentionally simplify the measure of natural light to the proportion of the patient beds that have access to southern daylight. The reason is that we recognize it as a principle that drives a lot of Chinese nursing unit design. In fact, it is specified in the *Architectural and Design Code for Chinese General Hospitals* that more than half of patient rooms should have access to southern sunlight (Ministry of Housing and Urban-Rural Development of the People's Republic of China [MOHURD] , et al., 2004b). A t-test demonstrated that the Chinese cases have significantly higher ratio of patient beds facing south ( $p < 0.05$ ) (Figure 6.55). It supported sub-proposition three.



**Figure 6.55: T-test on the ratio of patient beds with access to southern daylight between the U.S. and Chinese cases shows that Chinese cases have significantly higher ratio of patient beds facing south.**

### 6.4.4 Chinese Layouts Are More Driven By The Needs For Face-to-face

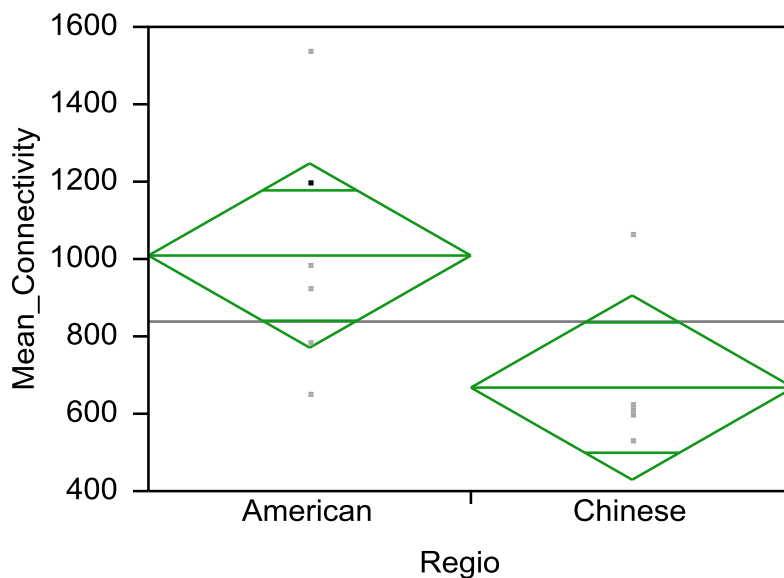
#### Communication

We further compared the spatial measures generated by visual graph analysis and axial map analysis on the selected Chinese and the U.S. exemplary nursing unit plans.

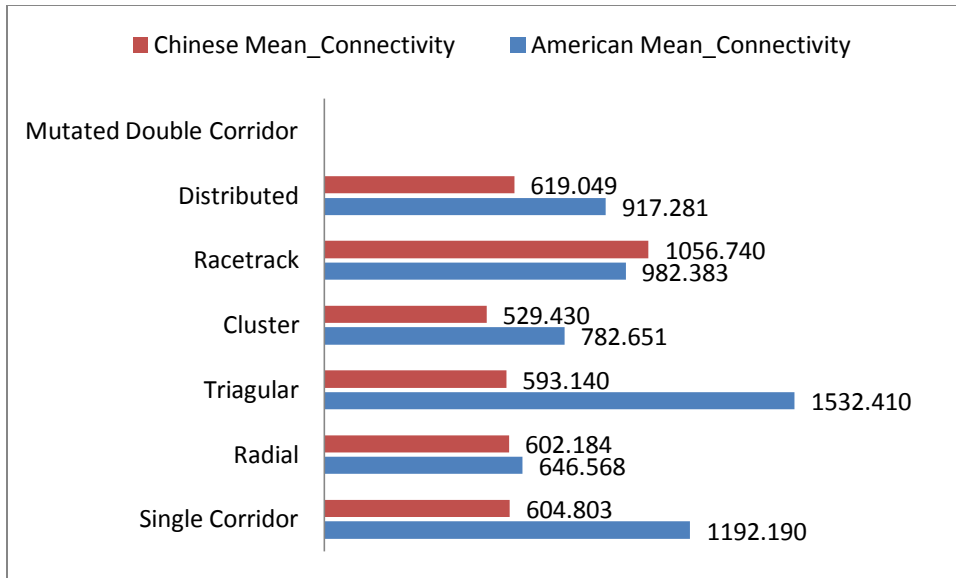
The purpose was to find out whether the cultural differences that we defined in Chapter Four were reflected in spatial configurations.

The results of the visual graph analysis showed that the mean connectivity values of the Chinese cases were statistically smaller than the U.S. ones ( $p < 0.05$ ), regardless which typology they applied (Figure 6.56). It demonstrates that at the local level the Chinese cases are visually less connected than the U.S. cases. The comparison of VGA between the U.S. and Chinese cases with the same typology also confirmed the trend (Figure 6.57).

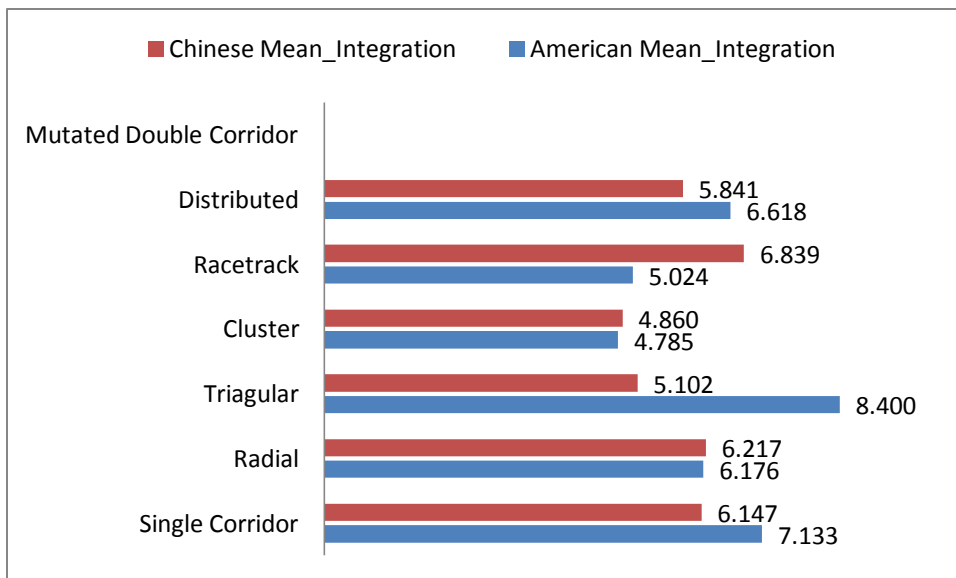
When we examined visual inter-connectedness at the global level, most Chinese cases had lower or comparable integration values than their U.S. counterparts with the same typology. The only exception was the cases for the racetrack typology (Figure 6.58). The low visual connectivity and integration values of the Chinese cases demonstrate that these nursing units are visually less connected at both the local and global level.



**Figure 6.56: T-test of the mean connectivity based on VGA between the U.S. and Chinese cases. The mean connectivity values of the Chinese cases were statistically smaller than the U.S. ones ( $p < 0.05$ ).**



**Figure 6.57: Comparison of the U.S. and Chinese VGA mean connectivity by country and typology. Most Chinese cases had lower mean connectivity values than their U.S. counterparts with the same typology.**

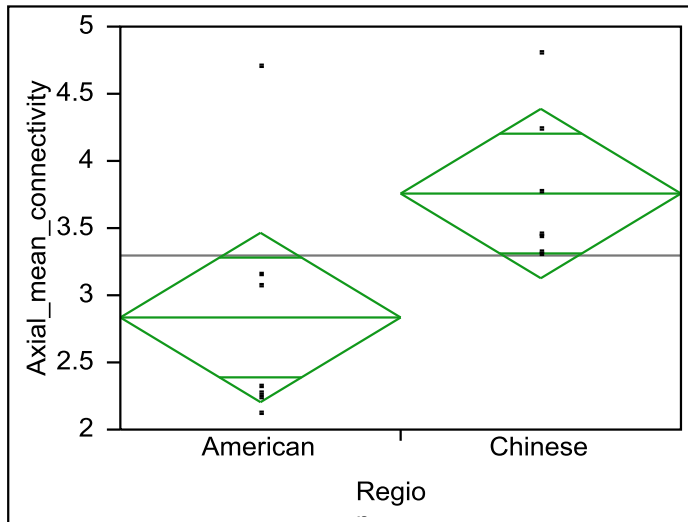


**Figure 6.58: Comparison of the U.S. and Chinese VGA mean integration by country and typology. Most Chinese cases had lower or comparable integration values than their U.S. counterparts with the same typology.**

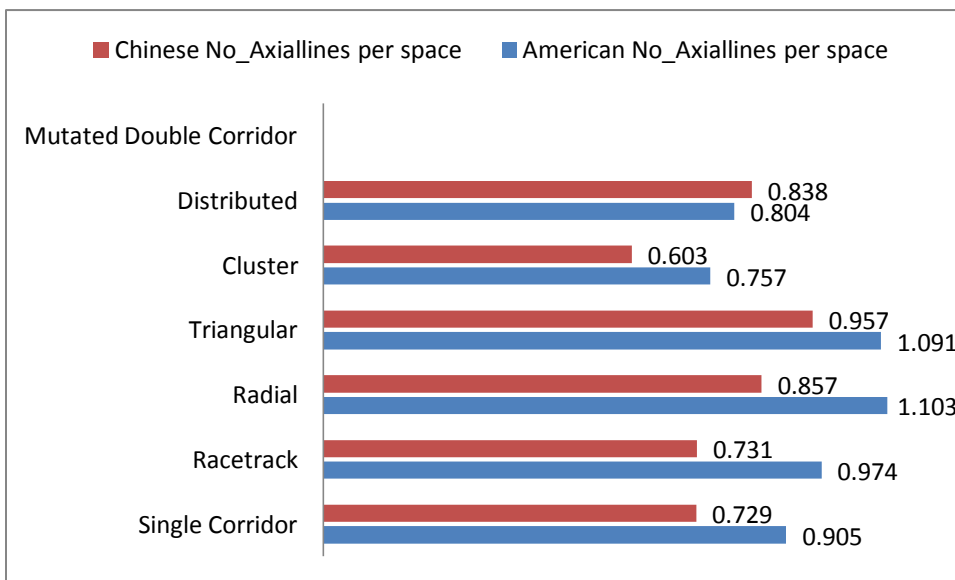
However, the comparison based on axial map analysis generated different patterns when compared to the results of the visual graph analysis. Firstly, the Chinese cases had statistically larger axial mean connectivity than the U.S. cases ( $P < 0.05$ ), regardless the nursing unit typologies that applied (Figure 6.59). Moreover, all of the Chinese cases had less or comparable number of axial lines per space than the U.S. cases (Figure 6.60). In addition, most of the Chinese cases had larger axial mean integration than the American cases, except the case of the triangular layout (Figure 6.61).

The results seem to conflict with those from prior visual graph analysis. Figure 6.62 below demonstrates that most of the Chinese nursing units had higher axial integration and lower visual integration when compared to the U.S. cases. In other words, most of the Chinese cases were physically more accessible but visually less connected at both the local and global scale when compared to the U.S. cases.

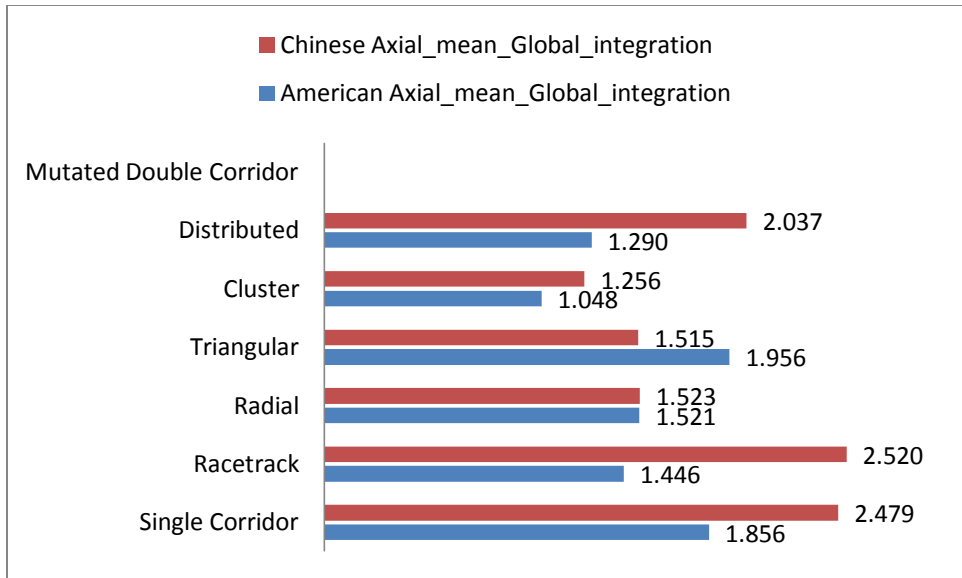
However, a closer examination of floor plans revealed disparate spatial strategies utilized in the U.S. and Chinese nursing unit designs. The U.S. cases tend to use below-eye-level furniture to define the spatial boundaries. The rich visual connections allow a good awareness of patients' condition and care coordination, yet restrict free movement. This spatial strategy strikes a balance between the needs for constant care coordination in nursing units and the individualism of the U.S. culture. On the contrary, the Chinese cases tend to define space with high walls. The reduced visual connections are complemented by the high physical accessibility both at local and global level. As a result, those layouts encourage movement and face-to-face communication, which is the preferred high-context communication style by Chinese. The statement of sub-proposition four is supported.



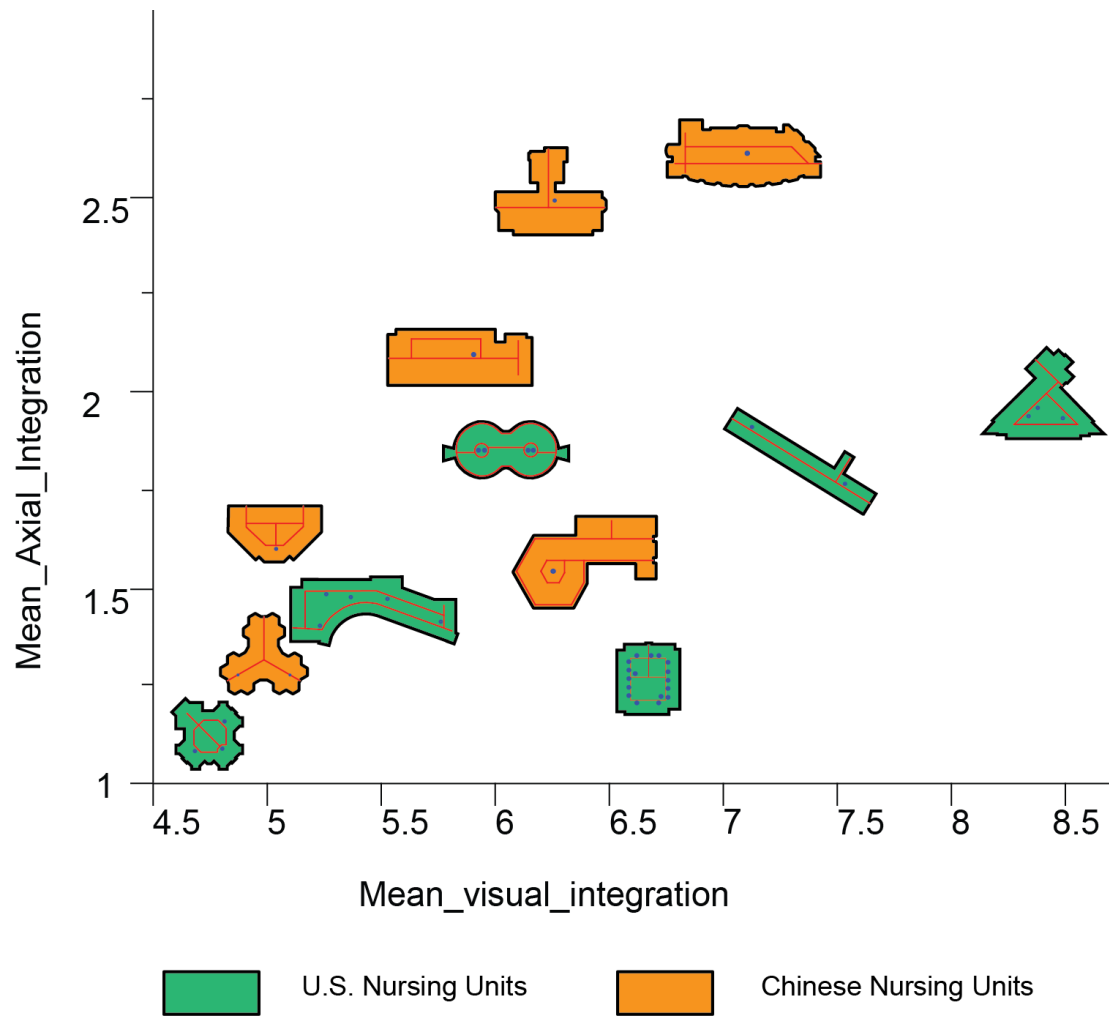
**Figure 6.59: T-test of the mean connectivity based on axial map analysis between the U.S. and Chinese cases. The Chinese cases had statistically larger axial mean connectivity than the U.S. cases ( $P < 0.05$ )**



**Figure 6.60: Comparison of number of axial lines by country and typology. All of the Chinese cases had less or comparable number of axial lines per space than the U.S. cases.**



**Figure 6.61: Comparison of mean integration of axial lines by country and typology. Most of the Chinese cases had larger axial mean integration than the U.S. cases, except the case of the triangular layout.**



**Figure 6.62:** Six U.S. and six Chinese nursing unit layouts compared according to mean axial integration (based on axial map analysis) and mean visual integration values (based on visual graph analysis). Most of the Chinese cases have higher axial integration and lower visual integration when compared to the U.S. cases.



#### **6.4.5 Chinese Layouts Have Stronger Sense of Hierarchy**

The evaluation of the integration values of various functional zones demonstrated that there were hierarchical orders in both U.S. and Chinese cases. In all cases but the Kaiser Foundation Health Center, the circulation zone had the highest integration value. In addition, in most cases, the nurse station was located at or close to the integration core to gain maximum visual connections to the whole unit.

In order to find out the cultural inequality genotype, we further compared the rank order of different space categories according to their integration values. Genotype is a concept used by Space Syntax scholars to describe ‘the constant relationship between spaces’, which is a reflection of cultural inputs in buildings (Hillier & Hanson, 1984). The results are surprising. For most typologies, the rank order of spaces in Chinese cases were consistent with the rank order in the U.S. cases with the same typology (Table 6.6). It shows that typological differences overweight national differences regarding the rank order of spaces for different user groups. For racetrack, radial, triangular, cluster, and distributed layout, the staff zone had larger visual integration value than the patient zone. In those layouts, patients had more privacy comparing to staff. For single corridor and mutated racetrack layout, the patient zone had larger visual integration value than the staff zone. Hence the staff zone in those layouts were visually less accessible, which represented higher status and stronger control over patients. As we have identified earlier in Chapter 2, the single corridor and mutated racetrack layouts are two of the most popular typologies applied in China, representing a majority of total Chinese nursing units. We speculate that besides the consideration on space economy, staff efficiency, and maximum access to southern sunlight, these two typologies are widely adopted probably due to the hierarchical order of the configuration that pertains to the high power distance in China.

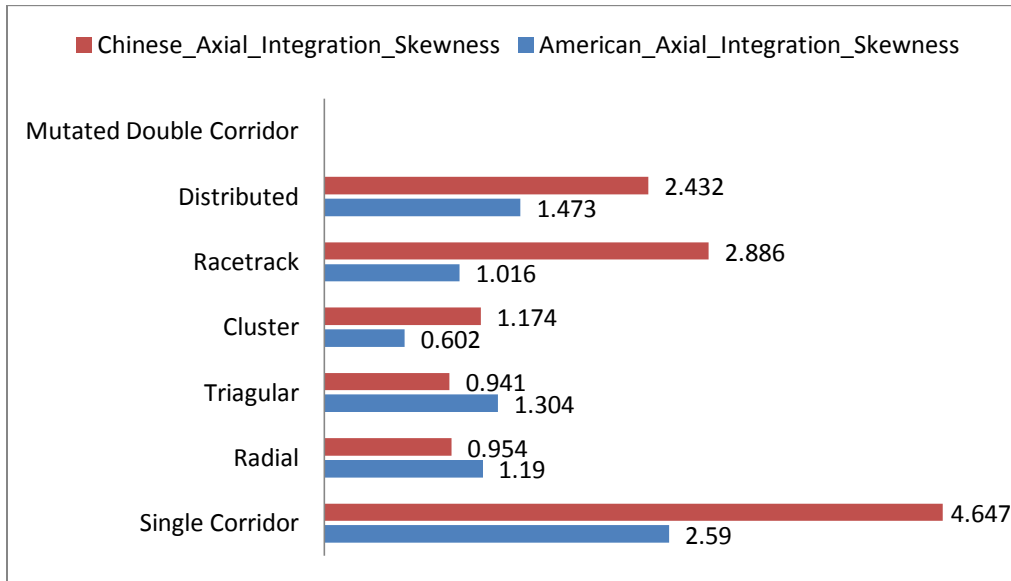
**Table 6.6: Rank order of various space categories of the U.S. and Chinese cases according to the integration values.**

Typology	Rank order of Integration of Spaces in the U.S. Cases	Rank order of Integration of Spaces in Chinese Cases
Single Corridor	C>P>S	C>P>S
Racetrack	C>S>P	C>S>P
Radial	S>C >P	C>S>P
Triangular	C>S>P	C>S>P
Cluster	C>S>P	C>S>P
Distributed	C>S>P	N/A
Mutated racetrack	N/A	C>P>S

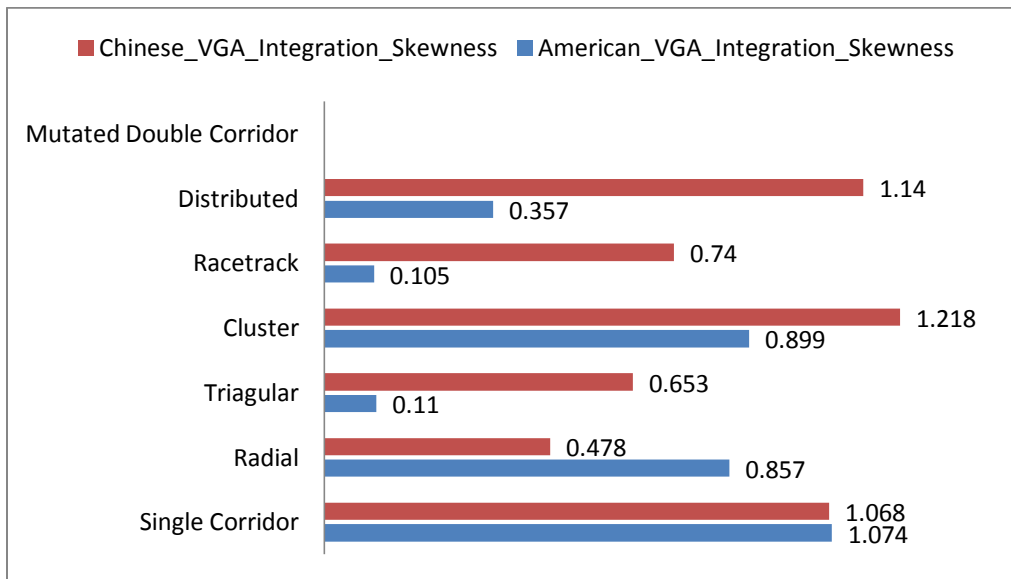
C: circulation, S: staff zone, P: patient zone

Although both U.S. and Chinese cases displayed spatial hierarchy in their configurations, the degree of the hierarchy might vary. We further tested this with the skewness of the distribution of their integration values. Skewness is a measure of the asymmetry of the probability distribution of a random variable. The skewness value can be positive or negative. When the skewness value approaches to zero, the values are relatively evenly distributed on both sides of the mean value. Therefore, the larger the skewness value is, the more unevenly distributed the values are. Here we calculated the skewness of the distribution of integration values of both visibility and accessibility. Although the differences were not statistically significant, there was a strong trend that the Chinese cases had larger skewness values than the U.S. cases with the same typology (Figure 6.63 and Figure 6.64). It indicates that the integration values of various functional zones in Chinese cases present larger variances when compared to those in U.S. cases. In other words, different functional zones in Chinese cases have quite disparate visibility and accessibility. In addition, a strong spatial hierarchy was manifest in circulation system of Chinese layouts represented by the axial maps. In general, there were clear hierarchy between the public and private circulations. The public space such as patient zone is connected by primary order circulation; and the more private staff offices and support areas are connected by secondary order circulation. Hence, we speculate that the

Chinese cases have stronger spatial hierarchy than their U.S. counterparts that apply the same typology. The results supported the sub-proposition five.



**Figure 6.63: Comparison of the Skewness of the distribution of axial integration values by country and typology.**



**Figure 6.64: Comparison of the Skewness of the distribution of VGA integration values by country and typology.**

#### **6.4.6 Chinese Layouts Have Stronger Sense of Territoriality**

The sense of territoriality is examined through both the integration values of various zones and the structure of the colored axial maps. As we mentioned earlier, in Chinese layouts, the patient zone and the staff zone have larger difference in integration values when compared to the U.S. layouts, which demonstrated clearer sense of territoriality.

The structures of colored axial maps also demonstrated that there was a strong sense of territoriality in most Chinese cases. A clear demarcation of boundary existed between spaces with different programmatic functions. In most of the Chinese cases, staffs were co-located in one zone with well defined boundaries. Whereas in the U.S. cases, the sense of boundary was diminished by either breaking down the staff zone or linking it with other zones with highly integrated axial lines. The transpatial design without an identifiable spatial focus is a reflection of individualism and the attribute orientation of the U.S. culture. By contrast, collectivism and the frame orientation of Chinese culture is better supported by a configuration with clearly defined boundaries and close connections within the group. Thus the sub-proposition six is supported.

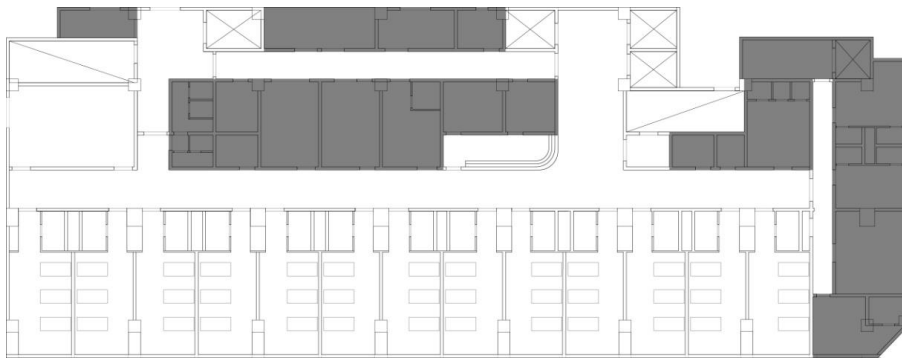
#### **6.4.7 Chinese Layouts Have Larger Ratio of Backstage Space**

In order to test the sub-proposition seven, we further calculated the frontstage and backstage space in the selected Chinese and U.S. nursing units. Based on Goffman (1959)'s definition, frontstage is where performance related information is "in play" while backstage is where suppressed information makes an appearance. In this thesis, we specified the frontstage as the space where patients and visitors could directly see and/or access, whereas the backstage as the space where patients and visitors had no direct visual or physical access. The intention was to find out to what extend that staffs' behavior were exposed to public, and to what extend that staffs have the security to raise

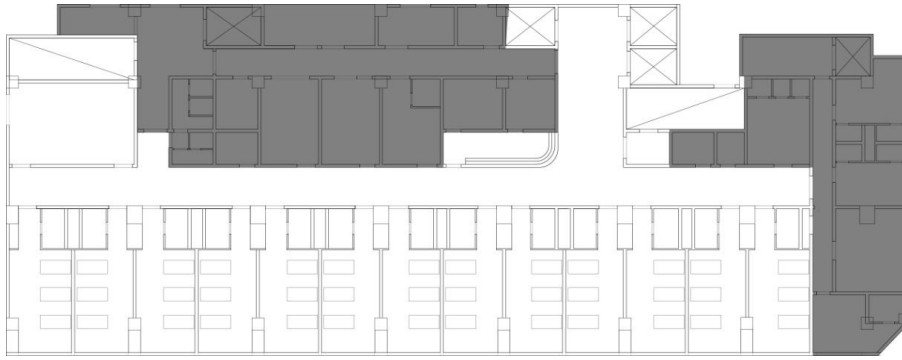
questions, clarify procedures, and challenge colleagues without the concern of losing face in public.

The calculations had two levels. We firstly computed the ratio of frontstage versus backstage in the staff zone. At this level, the frontstage space included nurse station, alcoves, and other open team work areas; and the backstage space included nurse offices, doctor offices, supply rooms, break rooms and other spaces that were not visible or accessible to patients (Figure 6.65). Secondly we computed the ratio of overall frontstage space versus backstage in the whole configuration. At this level, the frontstage space included not only the frontstage in the staff zone, but also patient rooms and circulation area where patients had visual or physical access to; and the backstage space included not only the backstage in the staff zone, but also circulation area where the access were limited for staff only (Figure 6.66).

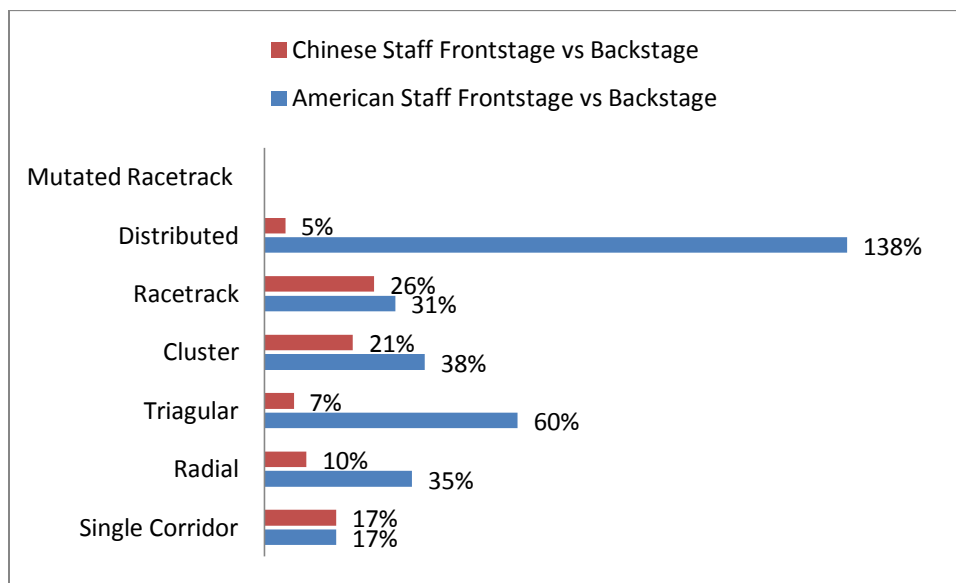
The analysis of the first level showed that all Chinese cases had comparable or smaller ratio of frontstage versus backstage space in the staff zone comparing to the U.S. cases (Figure 6.67). In addition, the t-test of the values based on the second level computation demonstrated that the U.S. cases had statistically significantly larger values of the ratio of the overall frontstage versus backstage space than the Chinese cases ( $p < 0.05$ ) (Figure 6.68). The results support our sub-proposition seven.



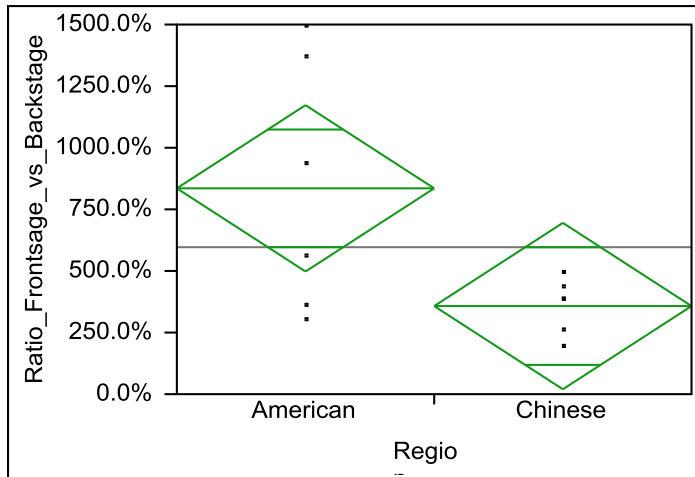
**Figure 6.65: Example of backstage space in the staff zone in Ruijin Hospital No.9 Building**



**Figure 6.66: Example of overall backstage space in Ruijin Hospital No.9 Building**



**Figure 6.67: Comparison of the ratio of frontstage versus backstage space in the staff zone by country and typology**



**Figure 6.68: T-test on the ratio of overall frontstage space versus backstage space between the U.S. and Chinese cases**

## 6.5 Summary

An in-depth analysis was conducted of six U.S. and six Chinese examples of nursing unit typologies. Their performance regarding economy, efficiency, visibility, and accessibility was measured. Comparisons were conducted at three levels, with regions controlled, with typologies controlled, plus an overall comparison.

The comparison of typologies within a single country produced similar results for both the U.S. and China. In both countries, the radial layout was most efficient with respect to the distance between nursing stations and patient rooms. In addition, in both countries, when considering rooms with multiple patient beds, the single corridor layout performed well, because it is the most economical in terms of the corridor length and area per bed. This layout is also quite efficient in terms of the average distance between nurse stations and patient beds. These advantages are part of the reason why the single corridor layout is still widely applied in China. However, because of the trend toward to double and single-bed rooms, the single corridor layout in China will become less economical and efficient due to the increasing number of patient rooms, and the resulting increase in the length of corridors. When efficiency and economy were evaluated on the basis of

patient rooms instead of patient beds, the distributed and cluster layouts were found to outperform the single corridor layout.

Significant national differences in the application of unit typologies were revealed in two separate analyses: in the U.S. and Chinese cases sharing the same typology, and the overall comparison. Most of the Chinese units studied have at least 50% south-facing patient rooms to ensure that patients have maximum access to southern sunlight. Secondly, the Chinese designs were more economical than the U.S. ones, with a smaller area per bed and a shorter corridor length per bed. In addition, Chinese nursing units have a higher ratio of patients per nurse station than the U.S. ones. The Chinese designs were more efficient than the U.S. ones with a shorter average distance from nursing stations to patient beds. The high efficiency and economy in Chinese units was achieved by the strategy of arranging multiple beds in patient rooms. Moreover, the Chinese cases demonstrated stronger spatial hierarchy and territoriality than the U.S. cases, and had a larger amount of backstage area. In addition, the configurations of the Chinese cases better encouraged face-to-face communication and had a higher level of physical accessibility.

The analysis shows that Chinese nursing unit designs have been modified from the Western precedents to adapt them to local economic conditions, different requirements for efficiency, the Chinese preference for southern natural light and good ventilation for flow of positive energy (*Qi*), the task-based care model, and the unique socio-cultural needs as defined by the Chinese national schema. Designers have to pay special attention to those needs when they attempt to transfer innovations from Western nursing unit designs to China. For instance, the distributed layout might not be as effective in China without the support of the team-based care model and appropriate staffing. In addition, modifications have to be made to the distributed layout to maintain



close connections among care givers and to provide a backstage space to support their communicational needs.

### **SECTION III: INTEGRATED DISCUSSION**

## **CHAPTER 7**

### **DISCUSSION AND CONCLUSION**

This chapter summarizes the findings that have come out of this thesis based on theoretical explorations and comparative case studies. The implications of these findings are discussed at theoretical, methodological, and practical levels. It then concludes with a discussion of the limitations of the present research, and suggests directions for future studies.

#### **7.1 Major Findings**

This study opened with the question of whether seemingly modernized Chinese nursing units still retained certain characteristics of Chinese socio-cultural preferences. The particular socio-cultural factors under consideration in this study focused on communicational needs that had been identified as being very important for the optimum organizational performance of nursing units. The study identified these needs through a thorough review of both the national schema and the organizational culture of Chinese nursing units. The specific communicational needs of Chinese care teams were then translated into spatial metrics based on an extensive review of previous space syntax studies on spatial configurations and communication.

In order to find out whether Chinese nursing unit designs have been adapted to fit specific models of communications which were strongly influenced by culture, an in-depth comparative study was developed that included six U.S. and six Chinese nursing units, with each representing an example of one nursing unit typology. The comparisons were conducted under a holistic framework encompassing four main factors as drivers of nursing unit designs: space economy, staff efficiency, access to southern natural light, and cultural preferences of face-to-face communication. Key metrics were proposed for a quantitative evaluation of each factor. For space economy, measurements included

corridor length per bed, corridor length per patient room, area per bed, and the composition of various zones. Staff efficiency measures included furthest distance from nursing station(s) to patient rooms, average distance from nursing station(s) to patient rooms, and average distance from nursing station(s) to patient beds. For natural light, the percentage of patient beds that have access to southern sunlight was calculated. To evaluate how space supported cultural preferences of communication, spatial metrics were proposed, including mean connectivity, mean integration, speech intelligibility, and the rank order of integration values of various functional zones for the analysis on visibility and accessibility. The number of axial lines per space and the structure of colored axial maps were also taken into consideration. Using those metrics, three levels of comparisons were conducted on the case studies representing twelve nursing unit typologies: the first level within the same country, the second level within the same typology, and the third with both national and typological differences considered. Detailed results for each level of comparison are reported as following.

### **7.1.1 The Impacts of Nursing Unit Typologies on Performance**

The results of the first-level comparison showed results that were similar to those of prior studies on nursing unit typologies (James & Tatton-Brown, 1986; Shepley & Davies, 2003; Thompson & Goldin, 1975; Trites, et al., 1970).

- 1) For corridor length per bed, most typologies with redundant compound circulation themes were less economical than those with simple circulation themes. Both the Chinese and U.S. cases of single corridor layout had the shortest corridor length per bed.
- 2) Moreover, both types of single corridor layouts had the smallest area per patient bed among all the cases for each country.
- 3) However, the single corridor layouts did not score as high in terms of staff efficiency. The U.S. example of single corridor typology had the longest distance

between the nurse station and the furthest patient bed, and the longest average distance between the nurse station and patient rooms. The Chinese example of single corridor typology was also less efficient than the cases of radial and cluster layouts.

- 4) In both countries, the radial layout was the most efficient among all the typologies in terms of the average distance from nurse station to patient rooms.
- 5) Besides typology, number of beds per patient room was another important factor that affected the space economy and staff efficiency of a nursing unit layout. For instance, owing to the arrangement of multiple-bed patient rooms, the examples of single corridor layouts from both countries had quite small average distances from nursing stations to patient beds.
- 6) Among the six U.S. cases, the example of the triangular layout had the highest visibility and accessibility both at local and global scale. Among the six Chinese cases, the plan of the racetrack layout was best interconnected visually and physically. In both countries, the cluster layout had the lowest axial mean integration value, which implies the weakest accessibility at the global level. The nurse stations in the radial layouts in both countries had fairly high integration values; therefore they provide good surveillance of the overall units.

These findings show that nursing unit typologies do have strong impacts on space economy, staff efficiency, and spatial properties such as visibility and accessibility. In addition, during the second and third level comparisons of the U.S. and Chinese cases, the considerations of nursing unit typologies help generate cross-cultural commonalities and reveal dissimilarities in design. For instance, when we considered the U.S. cases and Chinese cases each as a whole set and conducted t-test on them, only few metrics showed statistically significant differences. However, once we matched the U.S. and Chinese cases by typology, their differences were much more

evident. It shows that nursing unit typology, which is categorized by floorplate shapes, circulation scheme, and distribution of nurse station(s), plays an important role in the performance of a layout.

### **7.1.2 Cultural Dimensions of Nursing Unit Design**

This thesis also revealed national differences when various typologies were applied in these two countries. The findings are listed as follows.

#### **7.1.2.1 Chinese Layouts Were More Economical In Terms of Space Allocation**

The Chinese cases had statistically significant, smaller areas per patient bed than the U.S. cases ( $p < 0.05$ ). Therefore, sub-proposition one is partially supported, in that the Chinese designs were more economical than the U.S. ones in terms of area per bed.

A strong characteristic of the Chinese nursing units was that they had longer corridor lengths per patient room, but smaller corridor lengths per patient bed than the U.S. cases. Thus, with respect to corridor length, sub-proposition one is partially supported, in that the Chinese designs were more economical than the U.S. ones. Besides nursing unit typology, the number of beds per patient room was an important factor that impacts space economy.

#### **7.1.2.2 Chinese Layouts Were More Efficient**

The U.S. cases had fewer patient beds per nurses' station than the Chinese cases. The difference was statistically significant ( $p < 0.05$ ). More importantly, Chinese nursing units had smaller average distances from nursing stations to patient beds than was the case in the U.S. nursing units. This finding supports sub-proposition two.

#### **7.1.2.3 Chinese Patient Beds In Chinese Nursing Units Had More Access To Southern Sunlight Exposure**

The Chinese cases had a significantly higher ratio of patient beds that have direct access to southern sunlight exposure than the U.S. cases ( $p < 0.001$ ). Sub-proposition three is therefore strongly supported.

#### 7.1.2.4 Chinese Layouts Were More Driven By The Needs For Face-to-face Communication

The Chinese cases had significantly lower mean visual connectivity ( $p < 0.05$ ) and much lower mean visual integration values compared to the U.S. cases. However, with respect to physical accessibility, the Chinese cases had significantly higher mean connectivity ( $p < 0.05$ ), much higher mean integration, and a lower number of axial lines per space than the U.S. cases. The results show dissimilar spatial strategies applied in the U.S. and Chinese nursing unit designs. The high visibility and low physical accessibility of the U.S. cases allow good awareness of patients' condition and care coordination, yet restrict free movement. It strikes a balance between the needs for constant care coordination in nursing units and the individualism of the U.S. culture. On the contrary, in the Chinese cases, the reduced visual connections are mitigated by the high physical accessibility both at local and global level. As a result, the Chinese layouts encourage movement and face-to-face communication, thus reflecting the collectivism and frame-based orientation of Chinese culture. The findings support the sub-proposition four.

#### 7.1.2.5 Chinese Layouts Demonstrated Stronger Sense of Hierarchy

Both the U.S. and Chinese cases demonstrated a sense of hierarchy in space, as the mean integration values for each functional zone, i.e. the staff zone, the patient zone, and the circulation area showed a hierarchical order. However, there was a strong trend that the Chinese cases had larger skewness values of the distribution of integration values than the U.S. cases with the same typology, although the difference was not statistically significant. We speculate that the integration values of various functional zones in

Chinese cases present larger variances when compared to those in the U.S. cases. In addition, a strong spatial hierarchy was manifest in circulation system of Chinese layouts represented by the axial maps. The results support the sub-proposition five. The Chinese cases demonstrated stronger spatial hierarchy than their U.S. counterparts that apply the same typology.

#### 7.1.2.6 Chinese Layouts Showed Stronger Sense of Territoriality

In Chinese layouts, the patient zone and the staff zone had larger difference in integration values when compared to the U.S. layouts, which demonstrated clearer sense of territoriality. Moreover, the structures of colored axial maps also demonstrated that there was a strong sense of territoriality in most Chinese cases. In Chinese cases, there were well-connected local structures that were weakly connected to the global structure. In the American cases, there was no clear local structure. The sense of boundary was diminished by either breaking down the staff zone or linking it with other zones with highly integrated axial lines. Thus the sub-proposition six is supported.

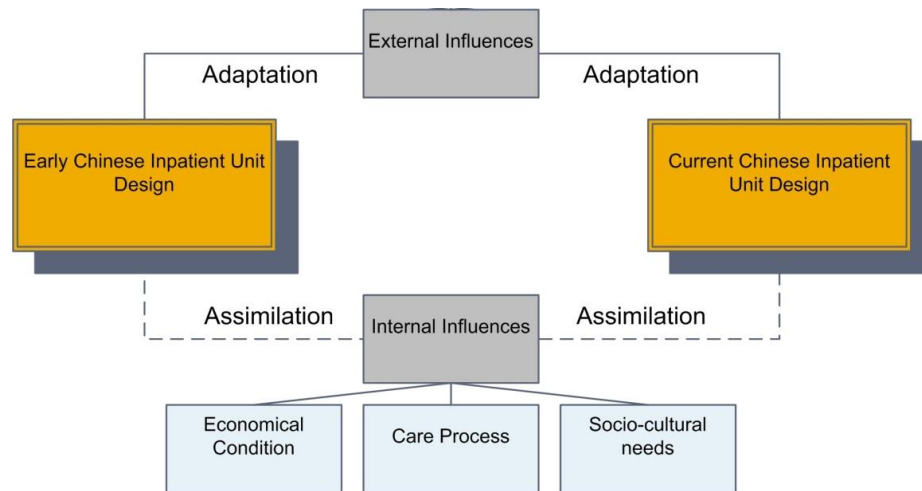
#### 7.1.2.7 Chinese Layouts Had Larger Ratio of Backstage Space

The U.S. cases had a significantly higher ratio of overall frontstage versus backstage area than the Chinese cases ( $p < 0.05$ ). Moreover, it was clearly evident that the Chinese cases had larger proportion of backstage space within the staff zone, which supported the Chinese cultural preference of preserving “face.” The findings support sub-proposition seven.

Based on the above findings, it is argued that the Chinese nursing unit designs are different from their U.S. counterparts because of socio-cultural factors. The spatial configurations of Chinese nursing unit designs have been modified to fit the socio-cultural needs of Chinese. This finding supports what Mary Brown Bullock (1980) has pointed out in her influential book “An American Transplant: The Rockefeller



Foundation and Peking Union Medical College.” She claimed that intercultural relations could not be simply described as “impact and response,” which is a one-way forceful transfer. Instead, it is based on “adaptation and assimilation.” Adapting means “to make suitable, especially by changing,” while assimilate means “to take up and make part of itself, or oneself.” In other words, the development of Chinese hospitals is based on “adaptation and assimilation” of external and internal influences (Figure 7.1).



**Figure 7.1: The external influences and internal influences on Chinese healthcare design**

### 7.1.3 The Interconnectedness of Design

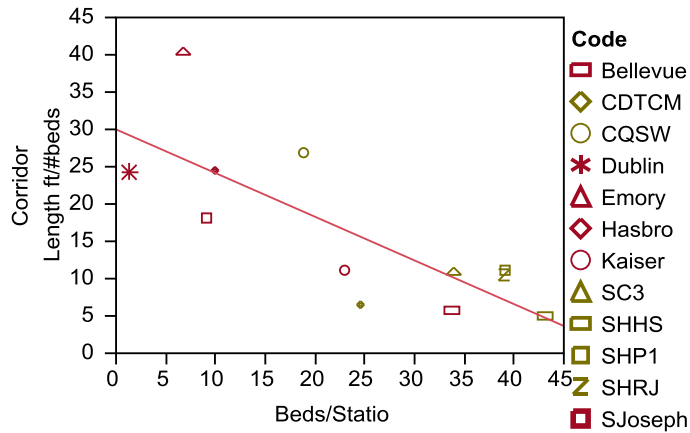
Another important finding of this thesis was the interconnectedness of design. This thesis treated nursing unit designs as reflections of the balancing act involving four main factors: space economy, staff efficiency, access to natural light and cultural preferences. For each factor, there were various metrics that were applied to evaluate different aspects of design. The comparisons of nursing unit typologies based on those metrics showed that each typology represented some compromise between those factors. A design might score high on one aspect, with trade-offs in other aspects.

Moreover, analysis showed there are interesting relationships among those metrics. The correlations among these metrics included:

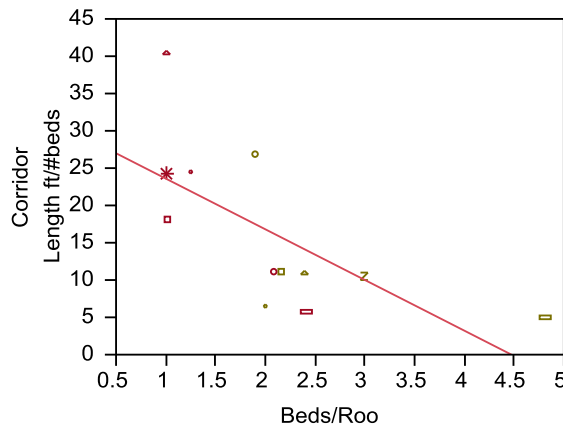
- 1) The number of beds per nurse station had a strong negative correlation with the corridor length per bed ( $R^2=0.611$ ,  $p<0.01$ ) (Figure 7.2). In addition, there was a weak negative correlation between the number of beds per patient room and the corridor length per bed ( $R^2=0.463$ ,  $p<0.05$ ) (Figure 7.3). In other words, the greater the number of beds that are assigned to each nurse station, and the more patients per room, the more compact or condense the layout might be, and therefore the shorter the corridor length per bed.
- 2) Two measures of space economy correlated to each other. The area per patient bed was correlated with the corridor length per bed ( $R^2=0.502$ ,  $p<0.01$ ) (Figure 7.4). It indicates that the longer corridor length that is needed to connect all patient beds, the less compact the layout will be, which is related to a larger area per patient bed.
- 3) There was also a close relationship between efficiency metrics. The average distance between nurse station and patient room was highly correlated with the distance between nurse station and the furthest patient room ( $R^2=0.850$ ,  $p<0.001$ ) (Figure 7.5). This shows that the shape of the floor plate has strong effects on efficiency, at least as related to walking distance. A more compact layout with a balanced relationship between nursing stations and all patient rooms usually leads to a smaller average walking distance from the nurse station to patient rooms.
- 4) There were no significant correlations between any staff efficiency measures and any space economy measures. It demonstrates that these two factors are independent from each other, thus representing quite different aspects of design. For instance, a design with short corridor length per patient bed does not necessarily result in short walking distances for nurses, if the relationship between the nurse station and patient rooms is not well planned.

- 5) The percentage of patient beds that have exposure to southern sunlight was correlated with several metrics regarding the arrangement of patient beds and space economy. It was strongly correlated with the number of beds per nurse station and the number of beds per patient room,  $R^2=0.828$ ,  $p<0.0001$ , and  $R^2=0.706$ ,  $p<0.001$  respectively (Figure 7.6, Figure 7.7). Moreover, it had a negative correlation with the area per patient bed, although the correlation was weak ( $R^2=0.372$ ,  $p<0.05$ ) (Figure 7.8). This indicates that the ratio of patient beds facing south has close relationship to the density of the layout. In order to allow more patient beds to be arranged along the southern façade of the building without making the southern façade impractically long, the layouts usually have to be very condensed with more beds in one patient room and a smaller area per bed.
- 6) The visual integration of nursing stations was strongly correlated with the mean visual integration of whole layout ( $R^2=0.742$ ,  $p<0.001$ ) (Figure 7.9). This result is not surprising, because in all twelve cases, the nurse station was located at or close to the integration core with the highest integration value. Therefore a nurse station in the most visually integrated layout tends to have the highest integration value.
- 7) There were weak correlations between mean axial integration and the number of beds per nurse station and the number of beds per patient room,  $R^2=0.468$ ,  $p<0.05$ , and  $R^2=0.408$ ,  $p<0.05$  respectively (Figure 7.10, Figure 7.11). The density of the arrangement of patient beds has significant effects on the interconnectedness of the layout with respect to accessibility. In other words, the higher the number of beds arranged in one patient room and around one nurse station, the more condensed the layout is, therefore fewer turns are needed to walk to all places in the configuration.

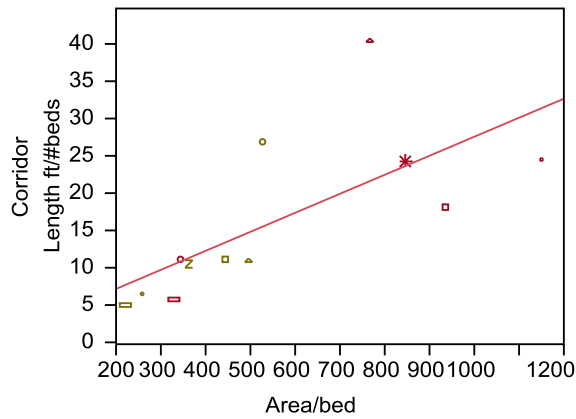
These results suggest that nursing unit design is an interconnected system. Decisions affecting certain aspects of a design may have significant impacts on other aspects. For instance, the design decision to use multiple-bed patient rooms versus single-bed patient rooms has implications not only on privacy and infection control, but also on the space economy and global accessibility.



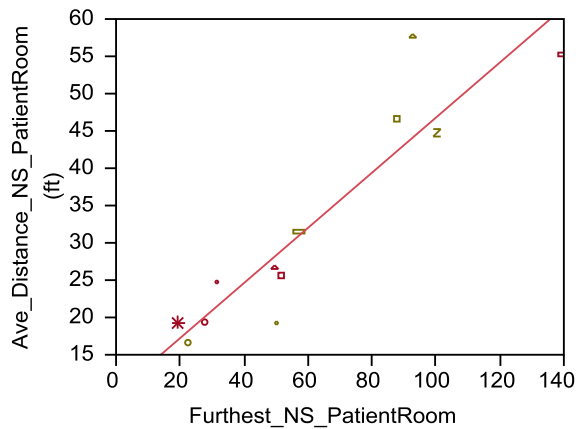
**Figure 7.2: Correlation between corridor length (ft) per bed and number of beds per station**  
( $R^2=0.611$ ,  $p<0.01$ )



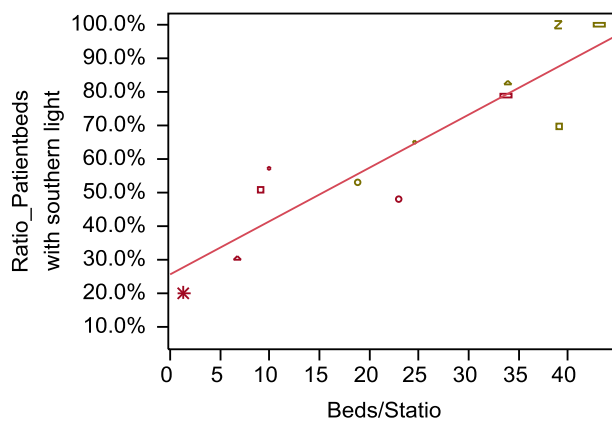
**Figure 7.3: Correlation between corridor length (ft) per bed and number of beds per room**  
( $R^2=0.463$ ,  $p<0.05$ )



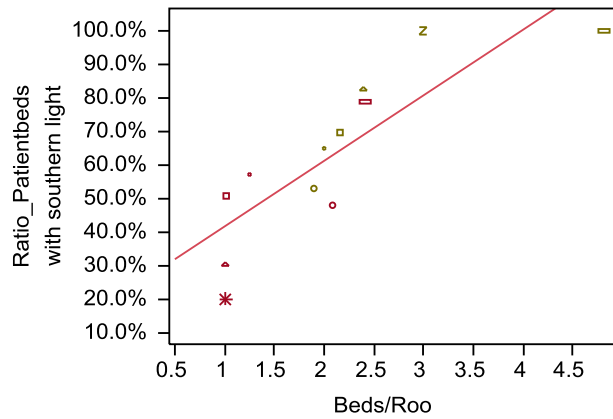
**Figure 7.4: Correlation between area per bed (ft) and corridor length per bed (ft) ( $R^2=0.502$ ,  $p<0.01$ )**



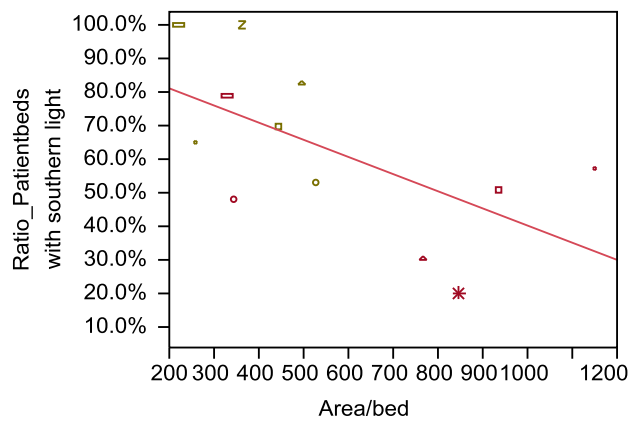
**Figure 7.5: Correlation between average distance from nurse station to patient rooms and the distance from nurse station to the furthest patient room ( $R^2=0.850$ ,  $p<0.001$ )**



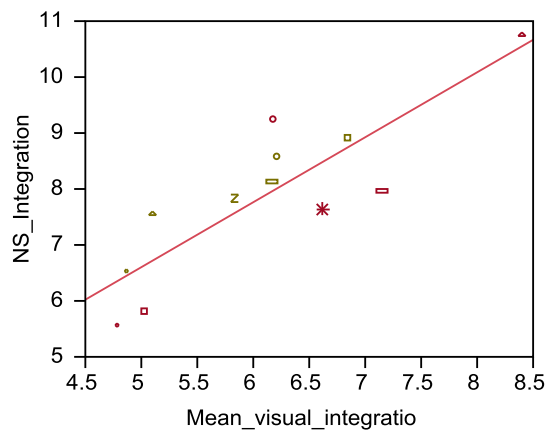
**Figure 7.6: Correlation between the ratio of patient beds with access to southern sunlight and the number of beds per nurse station ( $R^2=0.828$ ,  $p<0.0001$ )**



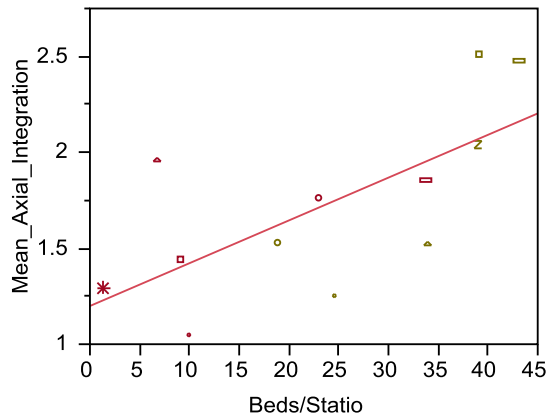
**Figure 7.7: Correlation between the ratio of patient beds with access to southern sunlight and the number of beds per patient room ( $R^2=0.706$ ,  $p<0.001$ )**



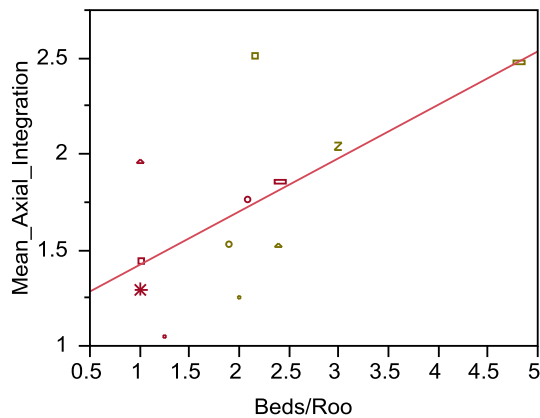
**Figure 7.8: Correlation between the ratio of patient beds with access to southern sunlight and the area per patient bed ( $R^2=0.372$ ,  $p<0.05$ )**



**Figure 7.9: Correlation between the integration of nurse station and mean visual integration ( $R^2=0.742$ ,  $p<0.001$ )**



**Figure 7.10: Correlation between mean axial integration and number of beds per nurse station**  
( $R^2=0.468$ ,  $p<0.05$ )



**Figure 7.11: Correlation between mean axial integration and the number of beds per patient room**  
( $R^2=0.408$ ,  $p<0.05$ )

## 7.2 Research Contributions

This study is the first of its kind exploring the cultural dimensions of nursing unit designs. It provides a comprehensive description of the design evolution of Chinese healthcare architecture, with a special focus on nursing units. Moreover, it provides an in-depth examination of the relationship between nursing unit typologies, communication, and the complexity of national and organizational culture in healthcare settings through extensive theoretical explorations and comparative case studies. The contributions of this study can be appreciated at three levels.

### **7.2.1 Theoretical Contribution**

From a theoretical perspective, this study provides a holistic framework illustrating the interplay of key factors that drive the architectural form of nursing units. More importantly, among these factors, culture has been identified as an invisible yet indispensable aspect of nursing unit design. This dissertation presents a conceptual model that helps to identify cultural variants as part of national schema and organizational cultures, in addition to representing them as characteristics of organizational communication, and further translates them into spatial variables. The link between culture and space is a key step in demonstrating how spatial form is the result of an interaction between the social logic of space and the spatial logic of society. In other words, the model presented here helps to understand how space embodies culture, and at the same time shapes behavior and leads to the evolution of culture. This theoretical framework could be applied beyond the Chinese nursing unit environment to other national or organizational cultural contexts.

### **7.2.2 Methodological Contribution**

From a methodological point of view, this study has translated abstract concepts and constructs and complex relationships into quantitative metrics. This thesis brings together knowledge and methods from multiple disciplines, including organizational communications, anthropology, healthcare, and architecture. Through an extensive review of cross-culture organizational communications and studies on Confucianism and the Chinese healthcare system, this study links culture to properties of communication. The theories and tools from space syntax were utilized to quantify building configurations and link them to communication patterns. This methodology allows the description of the generic properties of spatial layouts in a rigorous way, which makes the comparison of various building configurations possible. Therefore the methods developed



for this study can contribute to the understanding of cultural differences in healthcare design. The quantitative metrics developed here can also help designers evaluate implications of their design proposals and provide evidence for design decision-making.

### **7.2.3 Design Implications**

This study contributes to the development of spatial strategies for culturally conscious design in healthcare facilities. There are several factors that designers might keep in mind while designing nursing units for China. First of all, designs should take into account the specific socio-economic conditions in China. For instance, the low staff-to-patient ratio demands a design for nurse stations that includes good visual surveillance and short distances to all patient rooms. In addition, nursing unit typologies should be modified to allow patient rooms to have maximum access to southern sunlight. Moreover, designs have to take into consideration cultural preferences for face-to-face communication. A clear definition of the boundary between staff and patients is required to support the distinctions inherent in an in-group and out-group, collectivist culture. Within the staff zone, a large proportion of space should be designed as backstage space to reduce direct visual and physical access by patients and visitors. The backstage space should be locally well-connected to enable free physical movement and easy face-to-face communication for the care team. The findings of this thesis indicate that a fully distributed layout might not be appropriate for the Chinese context, since a dedicated team base might be essential to maintaining group identity. It shows that innovative U.S. designs cannot simply be copied in China without proper modifications to meet the cultural needs of the Chinese.

The cultural properties of communication also have implications on workplace design. Workplaces can be designed to mediate the misalignment between national culture and organizational culture. For instance, the office space for a multinational firm in China should balance both the national schema of Chinese employees and the

organizational culture of the parent firm for the effective operation of the organization. The location of walls, partitions, furnishings, and other barriers in the office environment should be manipulated to both maintain local work group cohesiveness and facilitate cross-group communications at the global scale.

More broadly, this thesis suggests a means to preserve the spirit of Chinese culture in modern design. Chinese architects have struggled to find the balance between tradition and modernity. Several approaches have been explored to search for identity in Chinese modern architecture. One popular approach is characterized as sentimental, scenographic regionalism with a strong dash of imperial nationalism. Chinese culture is simplified as symbolic representation of traditional architectural language or the imitation and amelioration of traditional architectural form. However these approaches focus on architecture style without much consideration for the use of space. This thesis offers an alternative conception of Chinese architectural tradition in terms of spatial organization. The findings presented here show that the nursing unit is a “borrowed” building type and a rigidly programmed space that still retains characteristics of Chinese spatial behavior. It therefore suggests the possibility that Chinese culture can be represented through properties of spatial configuration and incorporated into modern Chinese architecture.

### **7.3 Limitation and Future Research**

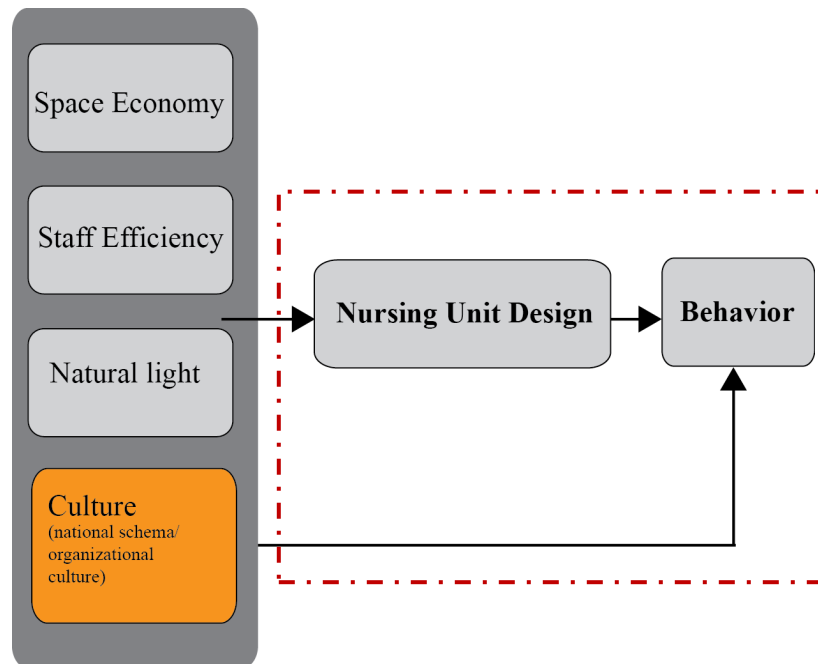
- 1) The first limitation of this study is related to the small number of cases selected for study. Only six cases from each country were considered. Moreover, the cases were not selected based on a random sampling. It raises the issue of whether these cases are truly representative. However, the purpose of this study was to provide insights into the role of culture in nursing unit design and to link it to quantifiable metrics through detailed case studies. Hence what is generalizable from this study is more of theory than the direct results. Yet the trends revealed in this study do help us start to see some causal relationships. The validity of these findings

should be further tested through future studies with a large sample size of cases and with better-controlled matching conditions such as size, year of construction, number of beds, function and service line of the units.

- 2) The operational significance and implications of the proposed spatial metrics are not yet proven. For instance, staff efficiency in this study is the theoretical metric based on direct measurement of the physical environment. It may not fully predict real performance in terms of nurses' actual walking distance. Further studies have to validate the metrics by linking the spatial measures to behavioral outcomes (Figure 7.12).

Additional work should also be done to discover the impacts of culture and inpatient unit design on the actual, observed patterns of organizational communication in Chinese nursing units. The related research questions that need to be answered include: what are the resulting patterns of encounters and communication among caregivers? How does the interaction between nursing unit design and culture impact organizational performance and outcomes such as social support and staff satisfaction?

In addition, it is recognized that the organizational culture of hospitals in China is in the process of changing. Future studies should explore whether there are clashes or misalignments between Chinese national culture and the rapidly-evolving "care culture," and whether space design can help solve these conflicts and contribute to the change of organizational culture and transition of organizational culture in Chinese hospitals.



**Figure 7.12: Future work should be done to evaluate the impacts of culture and space on behavior.**

- 3) Although some correlations were discovered among the proposed spatial metrics, more work is needed in order to precisely understand the way in which those metrics interact. It is necessary to conduct additional studies to determine the lower bounds of substantive differences in those metrics that would have significant impacts on efficiency, economy, and interaction. In addition, it would be interesting to observe real-life design processes to understand how designers prioritize various factors in nursing unit design, and how they evaluate the trade-offs when they make design decisions.
- 4) The fourth area warranting additional study relates to the accuracy and appropriateness of the metric regarding natural light. In this study, the metric for natural light was simplified as the ratio of south-facing patient beds, because the preference for southern sunlight drives a lot of Chinese nursing unit design. Admittedly, however, the issue of natural light is far more profound than the orientation of the building. It raises an interesting question about human experience. Evidence has shown that light impacts outcomes in healthcare settings,

resulting in the reduction of depression among patients, the improved quality of sleep, the ease of pain level, and the decrease of length of stay in hospitals (Joseph, 2006). It will be an important to study and define more rigorous and valid metrics for natural light that tie closely with human experience and patient outcomes, especially under different cultural contexts.

- 5) This thesis focuses primarily on the cultural impacts of organizational face-to-face communication from the point of view of staff members. Subsequent research should be conducted on the cultural differences between China and the United States regarding patients/families. For instance, the current tough requirements for space economy are not amendable to family presence. However, future designs will have to account for this, due to the strong family ties in the collectivistic Chinese culture. It would be interesting to examine the impacts of collectivism on patients' and families' perceptions of single- versus multiple-patient rooms and the issues related to family accommodation. In addition, the high power distance noted earlier may impede communication between patients/families and caregivers in patient-centered care. Future studies should explore these issues in order to recommend design practices that strike a balance between the cultural needs of maintaining large power inequalities and effective communication between patients/families and caregivers.

## APPENDIX A

### STUDIES ON ORGANIZATIONAL COMMUNICATION AND SPATIAL CONFIRGURATIONS

**Table A.1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications.**

Study	Author/ Year	Organization	Spatial Analysis	Spatial Measures	Organizational Measures	Research Methods	Statistics
Managing the Flow of Technology	Allen, 1977	R&D lab	N/A	Physical proximity	Communication	Survey	N/A
The social potential of buildings: spatial structure and the innovative milieu in scientific research laboratories	Penn & Hillier, 1992	R&D labs (X & Y)	Axial map	Global integration (RRA); local integration (RRA3);	Frequency of contact, and usefulness of the colleague	Spatial analysis, observations of space use patterns (behavior mapping), and questionnaire survey	Pearson correlation
Space, Education, and Socialization	Peatross & Peponis, 1995	Design studios	Axial map	Integration (RRA)	Presence, movement, and interaction	Spatial analysis, observation	Descriptive statistics
The Spatial Dimension of Control in Restrictive Settings	Peatross, 1997	Three Alzheimer's units and three juvenile detention centers	Axial map, animated isovist	Square footage of space or isovist or both combined (SQFT), connectivity (CON), and integration (1/RRA)	Movement, interaction	Spatial analysis, behavior mapping and tracking	Pearson correlation

**Table A.1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

<b>Study</b>	<b>Author/ Year</b>	<b>Organization</b>	<b>Spatial Analysis</b>	<b>Spatial Measures</b>	<b>Organizational Measures</b>	<b>Research Methods</b>	<b>Statistics</b>
Enhancing Communication in Lab-based Organizations	Wineman & Serrato, 1997	R&D lab (two research labs A&B)	Axial map; convex map; and analysis of visual fields	Global integration (RRA); local integration (RRA3);	Presence, and interaction	Spatial analysis, behavior data log through hand-held mini-recorders	Pearson correlation
The Space of Innovation: Interaction and Communication in the Work Environment	Penn et al., 1999	Advertisement agency (before and after study of company X and two floors of company Y)	All-line axial map	Integration (RRA), step depth from the entrance	Movement, co-presence and interaction	Spatial analysis, observation of space use (behavior mapping and tracking), and a questionnaire survey	Pearson correlation, multiple regression
Spatial and Communication Patterns in Research and Development Facilities	Serrato & Wineman, 1999	R&D lab	Axial map; convex map;	Global integration (RRA); local integration (RRA3); Intelligibility of local to global interface (connectivity value versus integration value); distance, occupation density, visual density , spatial integration of the office	Frequency, location, and status of interaction	Spatial analysis, behavior data log through hand-held mini-recorders	Pearson correlation

**Table A.1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

Study	Author /Year	Organization	Spatial Analysis	Spatial Measures	Organizational Measures	Research Methods	Statistics
Organizational constructs and the structure of space: A comparative study of office layouts	Rashid & Zimring, 2003	Government offices (five layouts)	Axial map	Integration, connectivity, length of the axial lines, the shape of integration core, the spatial hierarchy based on global and local accessibility defined by integration and connectivity values, the correlations of the local and global spatial variables	Communication, control, territoriality, privacy, and status	Spatial analysis, informal interviews, field observation (no behavioral data was presented in the paper)	Pearson correlation
Configuration and Design in Caring Environments: Syntax and quality of life in a sample of residential care homes for older people	Hanson & Zako, 2005	Residential care and nursing homes (36 cases)	Convex analysis, axial map	Axial global and local integration	Proportion of the residents' active time, frequency of the residents' enjoyable activity, the extent of the residents' choice and control over environment	Quality of life data observations; staff questionnaires; structured one-to-one interview with residents;	Pearson correlation



**Table A. 1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

Study	Author /Year	Organization	Spatial Analysis	Spatial Measures	Organizational Measures	Research Methods	Statistics
The Effects of Spatial Behaviors and Layout Attributes on Individuals' Perception of Psychosocial Constructs in Offices	Rashid et al., 2005	Governmental offices (four layouts)	Axial map	Integration, connectivity, length of the axial lines	Psychosocial constructs: privacy, communality, communication, control, territoriality, and safety; spatial behaviors: movement, face-to-face interaction, visible copresence	Spatial analysis, field observation with pre-defined route, and questionnaires survey	Pearson correlation for direct effects of the spatial behaviors and layout attributes on psychosocial constructs; multiple regressions for the indirect effects of the layout attributes on the relationship between spatial behaviors and psychosocial constructs.

**Table A.1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

Study	Author /Year	Organization	Spatial Analysis	Spatial Measures	Organizational Measures	Research Methods	Statistics
Spatial layout and face-to-face interaction in offices- a study of the mechanisms of spatial effects on face-to-face interaction	Rashid et al., 2006	Government offices (four layouts)	Axial map	integration, connectivity, ratio between integration and connectivity, number and length of axial lines	Movement, copresence, face-to-face interaction	Spatial analysis, behavior mapping/field observation followed pre-defined route and use segment as unit of analysis, informal interview	Pearson correlation
Structure, Agency, and Space in the Emergence of Organizational Culture	Penn et al., 2007	British museum	Axial map	Global integration, radius 3 integration of the axial map, step depth	N.A.	Spatial analysis, general observation without behavioral data	Na
Designing space to support knowledge work	Peponis et al., 2007	Communication design firm (before and after Thoughtform relocation)	Axial map, visibility graph analysis	Axial integration, axial connectivity, the total length of axial lines, depthmap integration, depthmap connectivity	Frequency of interaction, individuals' connectedness in social network	Spatial analysis, self assessment questionnaires, social network analysis	Pearson correlation for the effects of linear integration on an individual's position social network, Kendall correlation for the rankings of individuals' network

**Table A.1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

Study	Author /Year	Organization	Spatial Analysis	Spatial Measures	Organizational Measures	Research Methods	Statistics
Movement in workplace environments—configurational or programmed?	Sailer, 2007	University office, research organization	Axial map and segment map	Axial integration, metric integration, segment integration	Frequency of traces, sitting, standing, moving and interaction	Short interviews; spatial analysis including axial line maps and segment maps; behavior mapping and movement traces.	Pearson Correlation of integration and movement, curve fitting alpha-values against maximum reached R2 for all separate floors and wings
Effective workplaces: bridging the gap between architectural research and design practice	Sailer et al., 2007	UK based radio station (before and six months after the relocation)	Visual graph analysis	Visual integration, accessibility	Frequency of seeing others, the degree to which one thinks others are valuable to his work	Spatial analysis, observations and interaction questionnaires, Social network analysis	Pearson Correlation

**Table A.1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

Study	Author /Year	Organization	Spatial Analysis	Spatial Measures	Organizational Measures	Research Methods	Statistics
The performance of space—exploring social and spatial phenomena of interaction patterns in an organization	Sailer & Penn, 2007	University school in London	Axial and convex maps	Axial integration, metric integration, distance,	Numbers of static/moving people, betweenness of network, usefulness,	Qualitative method: interviews based on Grounded Theory; quantitative methods: Space Syntax and Social Network Analysis (based on questionnaires) and behavioral mapping	Pearson Correlation of perceived width and the numbers of static people, visibility of workstation and network betweenness, number of people sharing office with the importance (eigenvector), frequency of being seen with cumulated usefulness
Enhancing Workspace Performance: Predicting the Influence of Spatial and Psychosocial Factors on Job Satisfaction	Wineman & Adhya, 2007	Four U.S. federal offices	Axial maps	Connectivity, local integration	Psychosocial measures: privacy, interaction support, sense of community, and job satisfaction	Space syntax, survey questionnaires data of 329 employees, regression analysis (predictive models and path analysis)	Regression analysis (predictive models and path analysis)

**Table A.1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

Study	Author /Year	Organization	Spatial Analysis	Spatial Measures	Organizational Measures	Research Methods	Statistics
Space, behavior, and environmental perception in open-plan offices: a prospective study	Rashid, 2009	Two open-plan government offices (before and after move)	Axial map	Visibility, accessibility, length of axial lines	Movement, visible copresence, face-to-face interaction (all spatial behavioral data is normalized for 100ft (30m) long segments to remove the differential effects of the length of route segments. Organizational perceptual measures include: privacy, job satisfaction, individual commitment to the organization	Space syntax layout analysis, field observation with pre-defined route, and questionnaires survey	1. Correlation analysis between the three spatial measures and observed spatial behaviors.; 2. T-test for the differences of perceived privacy, job satisfaction, and commitment to the organization between the old and new offices; 3. zero-order correlation among three different measures of environmental perceptions

**Table A.1: Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

Study	Author /Year	Organization	Spatial Analysis	Spatial Measures	Organizational Measures	Research Methods	Statistics
Comparative studies of offices pre and post—how changing spatial configurations affect organizational behaviors	Sailer et al., 2009	Case one: pre-post study for a radio station case two: pre-post study of a large media corporation	Visual graph analysis	Integration, accessibility	Case one: overall interaction, egonet (mutual usefulness), case two: movement density (the number of movements occurring per square meter of circulation space and per hour)	Spatial analysis (depthmap), space observations, semi-structured interviews, questionnaires lead to SNA	Pearson correlation
Spatiality and transpatiality in workplace environments	Sailer & Penn, 2009	A university (pre/post), a research institute, and corporate media companies (pre/post)	Axial map	Axial mean depth, metric mean depth	Face-to-face interaction	Spatial analysis, ethnographic and targeted observation interview, questionnaires that lead to SNA + Netgraph+ distance of interaction types	Pearson correlation (correlate the axial mean depth and metric mean depth with observed movement flows)

**Table A.1 Summaries of the link between spatial measures and organizational measures in studies on organizational communication and spatial communications (continued).**

<b>Study</b>	<b>Author /Year</b>	<b>Organization</b>	<b>Spatial Analysis</b>	<b>Spatial Measures</b>	<b>Organizational Measures</b>	<b>Research Methods</b>	<b>Statistics</b>
Spatial and Social Networks in Organizational Innovation	Wineman et al., 2009	A professional school at the University of Michigan	Axial map	Integration, connectivity, and step depth through Depthmap	The coauthorship matrix is analyzed based on SNA software and coauthorship network map (SNA measures, network density, network structural holes, and centrality). Tie strength was determined by the number of articles coauthored.	Spatial analysis, SNA	The logistic regression analysis model (The authors regressed the likelihood of co-authorship on the distance between two authors.

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## **VITA**

### **HUI CAI**

Hui Cai was born in Jiangsu, China. She received her professional architectural degree from Southeast University in Nanjing, China and Master of Art in architecture from National University of Singapore before coming to Georgia Tech to pursue a doctorate in Evidence-based Design. She has involved both in design practice and research in China and Singapore for several years. Hui Cai is interested in the relationship between culture, human behavior and physical environment, especially in healthcare settings. Currently her research focuses on examining the cultural aspects of nursing unit designs, and the impacts of design on communication, implicit learning and multi-disciplinary collaboration in healthcare organizations. Her recent research on the impacts of decentralized nurse station on nurses' informal communication and coordination was awarded by the International Academy of Design and Health as the 2011 International Research Project Academy Award Winner.